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# JOURNAL

OF

# THE FRANKLIN INSTITUTE

OF THE

State of Pennsylvania,

AND

## AMERICAN REPERTORY

OF

MECHANICAL AND PHYSICAL SCIENCE,

CIVIL ENGINEERING, THE ARTS AND MANUFACTURES,

AND OF

AMERICAN AND OTHER PATENTED INVENTIONS.

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JULY, 1843.

# Civil Engineering.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

## *On Cast and Rolled Iron Rails for Railways.* By John C. Trautwine, *Civil Engineer and Architect.*

Although this subject has recently been much discussed, it does not appear to me that all the facts bearing upon it have been taken into consideration; or that all those which have been examined, have received that degree of attention which is requisite to a satisfactory solution of the question, which of these two materials is the more eligible for common railroad purposes?

It is not my intention here to enter upon an examination of all the various points of inquiry necessarily involved in a detailed investigation of this important question; but merely to draw attention to one or two matters connected with it, which have, as I conceive, either been overlooked by those who have hitherto had the subject under consideration, or have been deemed by them of less moment than I suppose them to be.

It is my opinion that injury has resulted from the fact that those gentlemen who have been most active in discussing the question, have, in too unqualified a manner, expressed themselves in favor of one material, or the other, as preferable *in all cases*, to the entire exclusion of the other: or, in other words, I conceive the question to be not an *abstract* one, but one dependent upon contingent circumstances, by which it becomes so modified as to render the one material preferable, in some cases; and the other, in others. I have myself recommended the adoption of a heavy cast-iron U-rail, on a railroad nearly one hundred miles in length, under my charge, from considerations of economy of original outlay, which attended that particular instance, and which happened to be, in that case, one of vital importance; combined with the peculiar difficulty that would necessarily be encountered in fabricating a rolled rail, in a section of country where it would be nearly impossible to obtain, or rather to retain, a sufficient number of experienced workmen for conducting an extensive rolling establishment uninterruptedly. Those who have embarked in such undertakings, under similar circumstances, can testify from experience how much importance is to be attached to this consideration.

Added to these reasons, it was my intention to employ engines with much less weight upon their drivers than is usual on most of our railroads; a point which, as I hope to show further on, has much to do in deciding the question of a choice between cast and rolled rails.

Those who advocate the future rejection of rolled rails "in toto," and the consequent adoption of cast-iron, urge, as the chief argument in support of their views, the splitting, or *lamination*, as it is more generally termed, which experience has shown to take place, to a very serious extent, in the rolled rails used on all our railroads.

Instead of lasting from forty, to one hundred years, which was the term of duration originally predicted for the rolled rail, the supposition being based upon the probable rate of wear, or diminution of material, as deduced from some limited experiments, it has, in fact, on most of our roads doing a heavy business, needed partial replacements within some six or eight years, with a prospect of requiring much more extensive renewals within a few years more.

I conceive, however, that this defect in the rolled rail is not one inherent in the nature of the material, but one admitting of remedies of easy application; and I will proceed to point out in what particulars I think changes should be made in the manufacture of the rolled rail, in order to diminish, if not entirely to remove, its liability to split.

In the manufacture of this rail, as is well known, the process of *piling* is necessarily employed; that is, a number of short, flat, pieces of iron are *piled* on top of each other, and the *pile* is placed in a heating furnace, where it is subjected to a temperature sufficient to bring the several pieces of which it is composed, to the welding point. When the pile has attained this point, it is withdrawn from the furnace, and, without loss of time, is rapidly passed through the successive rolls, by which its pieces are at the same time welded together, elongated, and shaped to the required section of the rail.

But, from want of proper attention on the part of the workmen, the pile is occasionally taken from the furnace before it has reached the welding point; and the consequence is, that the process of rolling does not always unite, or weld together, the several pieces into one mass, so effectually as is necessary for a good rail; and we therefore see that the weight of the engines afterwards separates them, or splits the rail.

I say the weight of the *engines*, because I am perfectly convinced, from close observation, that it is the great weight borne by their driving wheels, that does most of the injury. I have seen comparatively very little of this lamination in either edge-rails, or the common flat-bar, $\frac{5}{8}$ of an inch thick, where horses are used for the motive power, drawing cars having no greater loads than 1½ tons to a wheel; on the contrary, I have seen the five-eighths flat-bar laid even immediately upon *continuous granite sills*, (on which the splitting is more apt to occur than in any other situation,) which have for nearly ten years endured the passage of a very heavy traffic, not drawn by locomotives, without the splitting of a single bar; while the edge-rails on the adjoining parts of the road, over which precisely the same transportation has passed, drawn by locomotives, are split to a very serious extent.

During a personal examination of most of the railroads in the United States, this matter has, among others, received my close attention; and I feel confident that this lamination may be almost, if not entirely, prevented; 1st, (and principally,) by more care in the application of the welding heat;—2d, by so passing the pile through the rolls, that the finished rail shall always consist of laminæ lying parallel to the top and bottom of the rail, as in fig. 1, instead of perpendicular to them, as in fig. 2: and, 3d, by rounding off more boldly the edges of the upper table, or top of the rail. Of the first precaution, we have already spoken. As to the second, it appears to me that the arrangement of the laminæ indicated in the first figure, must, for reasons too evident to require explanation, present more resistance to splitting (though probably less to exfoliation) than that exhibited in the second figure; and this supposition is sustained by the fact, that the splitting does almost invariably occur in lines approaching to the vertical. From this fact, the deduction very naturally follows, that a different disposition of the laminæ would produce a different result; and it is perhaps owing, in a great measure, to the frequent occurrence (probably accidental) of a horizontal disposition of them, that we have not much more splitting than actually does occur.

Fig. 1.

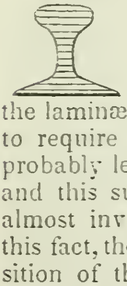
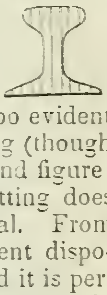


Fig. 2.



I have, it is true, in some rare instances, seen splitting occur in lines forming nearly a semi-circle, transversely of the rail; but these, I am inclined to believe, may be fairly ascribed to a very bad condition of the welding.

The necessity of the third precaution, or that of giving a bolder curvature to the upper edges of the rails, has also been impressed upon me by extensive observation.

It is plain that a great weight acting on a rail, the edges of whose top table are comparatively sharp, as in this figure, (3.) has a tendency to split them off; and when it happens, as it frequently does, that the line of welding of two of the original pieces of the pile lies near either of these edges, experience has shown that, if the welding be at all defective, such a splitting actually does take place.

Fig. 3.

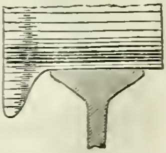
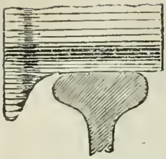


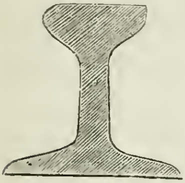
Fig. 4.



But, if we round off these edges, as in fig. 4, it is equally apparent that this splitting tendency must be materially diminished, inasmuch as the cohesion of a much more extended area must be overcome, before a piece can be separated.

I have universally observed so much less splitting in such rails as are boldly rounded at the top edges, than in those whose edges were comparatively sharp, that I have no doubt but that a still further extension of the same principle would be found to contribute considerably towards a correction of the evil, even if no very great improvement should be made in the welding.

Fig. 5.

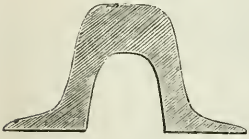


Many of our railroads have rails of the section, (fig. 5,) the upper edges of whose top are dissimilar, one being boldly rounded, while the other is left comparatively sharp. Such rails elucidate my views on this point in a very satisfactory manner; for I have observed that, in every instance, after having been for some time traversed by heavy engines, the outer, or sharp edge splits off badly, while the rounded, or inner one remains comparatively uninjured.

Consequently, this section of rail is objectionable, and I hope soon to see it fall into disuse. It was originally projected to save metal in the outer lip; but I am confident that the pecuniary advantage resulting from any such saving, is far more than countervailed by the diminution of strength attending it.

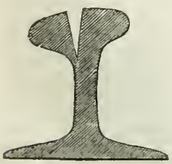
Moreover, there is another disadvantage attached to this section of rail, which is, that when the inner lip becomes worn away, as it will in time, especially on the outer lines of curves, the rail cannot be turned so as to make the original outer lip answer for the inner one. This turning of the rails I have frequently seen resorted to on the sharp curves of much-used railroads, and the rail should, by all means, be made with a view to this facility.

Fig. 6.



A bridge, or inverted U, rail, with the edges well rounded, as in this figure, (6,) will, I suspect, be found to resist splitting better than any form of section in present use; inasmuch as it not only presents a great extent of area of cohesion to be overcome before splitting can take place, but affords *less leverage* for the weight of the engines to act through to overcome it. In some cases,

Fig 7.



I have seen the T rail split in this manner, (fig. 7,) which proves that, in this section, the welding may, from want of care, be so very imperfect, that no rounding of the edges, alone, could prevent injury.

Such disruptions as this, evince very clearly, the utility of diminishing the *leverage* through which the disrupting weight may act.

The ordinary flat-bar furnishes strong evidence of the diminution of splitting arising from more perfect welding, combined with the parallelism of the laminæ with the top and base of the rail, aided by an absence of leverage; for it will be found, on examining such of our roads as are laid in part with the flat-bar, and in part with the T rail, that unless the latter be of an unusually strong pattern, it has split much more than the flat-bar.

The foregoing remarks will, I trust, sufficiently explain my reasons for not conceiving the splitting of the rolled rails to be attributable to any defect inherent in the nature of the material itself, but to other causes, which admit of easy remedy; and that, therefore, the principal argument adduced against the rolled rail, is not a tenable one.

Before I conclude this part of our subject, I will advance one suggestion, depending on the propriety of rounding more boldly the top edges of rails, that may possibly be of service on some of our railroads, on which the pattern for the rail to be used has not yet been decided on. It is this, that while we have been gradually increasing the *weight* of our rails, we have unfortunately overlooked the important consideration, *of applying the additional metal to the place where it is most needed.*

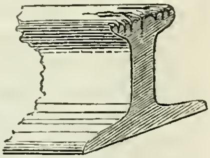
In consequence of this oversight, it will be found that some of our heavier, *improved* (?) rails, split to pieces sooner than some of the lighter ones have done, whose upper table was stouter, and better rounded.

I have had occasion to notice this more rapid deterioration of heavy rails, consequent upon want of just proportion in their parts, in more instances than one, upon very important lines of communication.

Another suggestion, having reference to the weight borne by the drivers of our engines, may not be deemed unimportant.

It is plain that, so long as we retain a top width of rail of about 2¼ inches, we cannot safely place, upon any one driving-wheel, a greater load than can be sustained without crushing, and splitting, by the ends of the rails, upon that width; otherwise the ends of the rails must be crushed, as shown in fig. 8. I shall do no more than allude to this point; my reason for introducing it is, that I feel very confident, from observation, that we have already, in some cases, exceeded the proper limit of load on a driver, warrantable by a top width of 2¼ inches.

Fig. 8.



The success which appears to attend the new *six-driver* freight-engine of that enterprising and skilful machinist, Matthias W. Baldwin, of this city, will go far towards arresting the destruction of our rolled rails. With a weight of but about two tons resting on each driver, she draws, with ease, trains weighing 200 tons over the 45 feet ascents on the Philadelphia and Columbia railroad; and the writer has seen her start, with apparent ease, a train weighing about 150 tons, up grades of 36 feet per mile, when the rails were in an unfavorable condition, being dusty, and slightly wet by a drizzling rain, which began to fall just at the time.

An increase in the number of drivers to our locomotives, which will enable us to diminish the weight borne by each, while, at the same time, it increases the total amount of adhesion, thus enabling us to draw heavier trains with less injury to the rails and other portions of the superstructure, I look upon as the greatest desideratum demanded, at the present day, towards perfecting the railroad system.

The advocates for cast-iron rails appear to conceive that material to be free from the danger of splitting on its upper edges, found so objectionable in our present rolled rails. But this is an error; for, unless the upper edges of the cast rail, also, be well rounded, they will be found to be fully as liable to that defect as the rolled rail. The pieces split off will not, it is true, be so long as those which separate from the rolled rail, owing to the granular structure of cast-iron; but their greater number will more than compensate for their difference in length.

From the observations I have made on rails of this material, I find that the splitting, in the case of sharp-edged rails, takes place on the outer edge to a greater extent than on the inner one; and for this reason: the friction of the flanches against the inner edge of the rails has a tendency to wear that edge gradually into a curve, conformable to that which unites the flanch to the tread of the wheel; and this curve operates as a partial protection against splitting, on the principle already alluded to, when speaking of the upper edges of rolled rails.

This action is particularly observable in the outer rails of sudden curves, where the inner edge soon becomes smoothly worn to a bold curve, which acts as a complete preservative against splitting, while the outer edges of the same rails become much injured. On straight lines, the splitting under heavy engines is very serious on both edges, if they be not well rounded; but it is perceptibly greater on the outer one. I have observed the same protective tendency of the outward pressure of the flanches very sensibly exhibited also in some rolled rails which have sharp edges.

By rounding off the edges of the cast rail about as boldly as is done in our best heavy rolled rails, and at the same time diminishing the weight borne by any one driving-wheel to about 1½ tons, I think we should prevent either splitting, or very serious abrasion; and I should not hesitate to employ such a rail, under such circumstances, whenever important considerations should happen to demand it.

We will now glance rapidly at two of the principal objections urged against the cast-iron rail, viz., its brittleness, and its more rapid wear.

Admitting, of course, the former objection, the friends of the cast rail propose to obviate it by the use of continuous wooden bearings. But this expedient, although unquestionably effective so far as it removes the danger of the rails breaking, will, on calculation, be found, in many cases, to raise the cost of the cast-iron track to an equality with one of rolled iron, in which the continuous bearings are not employed; and especially will this remark apply if the bearings be Kyanized.

This consideration neutralizes, in a great measure, one of the principal arguments in favor of the cast rail, viz., its comparative cheapness.

But, in cases where it is determined either to adopt, or to dispense with, bearing timbers, whether the rail be cast, or rolled, there the proportion of expense is entirely in favor of cast-iron; even when the latter has given to it an increase of weight over that of the former, sufficient to impart to it an equality of strength.

As to the *wear* of cast-iron rails, it cannot, I think, be denied that it is much greater than that of the rolled rails. According to experiments cited in "Wood on Railroads," the comparative wear is shown to be about as 4 or 5 to 1.

He says, (see 3d London edition, page 67:)

"We shall now give some of the results of the wear of cast and wrought-iron rails, with a view of determining the depth of bearing surface.

"In the former edition of this work, we gave an account of two experiments, on the wear of cast and wrought-iron rails, upon the Stockton and Darlington railway, as follows:—*Malleable-iron rails*, 15 feet long, over which locomotive engines pass, weighing from 8 to 11 tons; wagons loaded, 4 tons each; 85,000 tons passed over in a year, exclusive of engines and empty wagons; weight of rail, 136½ pounds; loss of weight, in 12 months, 8 ounces; the breadth of the top of the rail, being 2¼ inches, gives one-tenth of a pound, per yard, per annum; and Mr. Story informs us that subsequent experiments furnish nearly the same results. In determining the premium for the best form of rail, for the London and Birmingham Railway Company, with Professor Barlow and Mr. Rastrick, we found the annual wear, estimated by some of the competitors, at one-sixth of a pound, per yard, per annum. Upon the Killingworth railway, I have had some of the rails, which were weighed and laid down in 1825, taken up and re-weighed; and find the average loss of weight of several rails, to have been eight pounds, for each 15-feet rail, in 12 years, which gives about one-eighth of a pound, per yard, per annum. These rails were laid down at a time when the manufacture of malleable-iron rails was not so well understood as at present; and, on examination, I found part of the loss of weight was attributable to exfoliation on the sides. About 100,000 tons of coals would pass over these rails annually, exclusive of the weight of the engines and empty carriages. Mr. Dixon, the resident engineer upon the Liverpool and Manchester railway, states the wear of the rails upon that railway to be one-tenth of a pound, per yard, per annum; which was determined by taking up three rails, cleaning and weighing them, and then, at the end of twelve months, taking them up again, cleaning and weighing them as before; and this being repeated for two years, the wear was found to be the same.

"We may, therefore, take the wear of the rails to be about one-tenth of a pound, per yard, per annum, which, supposing the whole to result from the wear on the upper surface, will be one-eighty-fourth part of an inch; if the top, or wearing part, of the rail were, therefore, an inch in depth, the rail would wear eighty-four years. The whole of the wear above alluded to does not, however take place upon the top; a part, though, probably, a very small portion, is attributable to exfoliation by the action of the air: supposing, however, that the wear by the action of the wheels amounts to one-tenth of a pound, per yard, per annum; if the top, or bearing part, of the rail be made an inch in depth, it will be sufficient for all the purposes required. Any increased depth and weight, which would not be required for above eighty years, would, at compound interest, at the end of that period, amount to a greater sum than it would be convenient to expend for such a purpose, considering the remote period at which it becomes useful."

Again: he says, (page 131)

"Experiments are going on at present, where both kinds of rails, accurately weighed, are laid down, and subjected to the passage of the same quantity of traffic over them; the result of these, so far as they have gone, is in favor of wrought-iron. In the operation of making the cast-iron rails, the surface is partially case-hardened in the casting; this may be seen in all cast-iron rails, extending to a certain depth from the surface. Any experiment, showing the comparative wear, must, therefore, be continued until after the outer hardened surface be worn through; and it is presumed that sufficient time has not yet elapsed to furnish this. We have, therefore, been obliged to reject the data founded on this mode of experimenting, and shall give the result of a different sort of test, more severe, and which, it is trusted, will be deemed sufficiently approximate to justify its presentation to the reader.

"Upon the Killingworth railway we had originally cast-iron wheels upon the locomotive engines; about four years ago, we adopted wrought-iron tires. Now, as we have, in this way, the relative wear of cast and wrought iron upon the wheels which run upon the rails; and as the nature of the action will operate nearly alike, whether upon the surface of the rails or of the wheels, we shall, by that means, have a pretty near approximation to the relative wear upon the rails. In this way, we have a considerably more severe test; as, if we take the quantity of traffic, equal to 2000 tons, passing along the railway daily, and suppose the carriages to convey three tons each, with 3-ft. wheels, the relative wear of the wheels and rails is as 53 : 1, nearly.

"The average wear of the cast-iron wheels was above half an inch in nine months; and, with the wrought-iron tire, the wear of one pair of wheels has been a quarter of an inch in three years, and, with three other engines, one-eighth of an inch in twelve months; making the wear, at least, as five to one in favor of wrought-iron. The actual wear of the rails will not be to the same extent as this, as the engine wheels sometimes slip round, or slide upon the rails, in bad weather. The wear of the wheels of the common carriages will not be so much, for the same reasons; but, although it should be observed, that, from this, we ought not to deduce the actual duration of wrought-iron rails, as, their surfaces being narrower than the wheels, the wear will be, perhaps, more than proportionably greater, yet the relative wear should, however, remain the same. We now give the following experiment made on the Stockton and Darlington railway:

"Cast-iron rails, 4 feet long, over which wagons only pass, weighing four tons each, when loaded; 86,000 tons passed over in a year, exclusive of wagons; weight of rail, 63 lbs.; loss of weight in twelve months, 8 oz. The loss of weight in malleable-iron rails was, in the same period, 8 ounces for 15 feet length; the same quantity of goods, 86,000 tons. This will give the difference of wear 15 : 4 in favor of wrought-iron rails.

"These experiments show that, if rails of the proper degree of strength be used, the durability is decidedly in favor of wrought-iron rails; and we have before observed, that, in rails properly manufactured, none of the exfoliation, or oxidation, originally dreaded, exists."

And again, in his appendix, (page 729,) he gives the following experiment:

"On the 10th of May, 1831, on the Liverpool line, a malleable-iron rail, 15 feet long, carefully cleaned, and weighing 177 lbs. $10\frac{1}{2}$ oz., was laid down. On the 10th of February, 1833, the same rail was taken up by Mr. J. Locke, then resident engineer on the line, and well cleaned as before, and weighed 176 lbs. 8 oz. It had consequently lost, in twenty-one months, a weight of $18\frac{1}{2}$ oz. The number of gross tons that had passed on the rail, during that time, was estimated at 600,000. Thus we see that with so considerable a tonnage, and with the velocity of the motion on that railway, the annual loss of the rail was only $\frac{1}{268}$ of its primitive weight; so that it would require more than a hundred years to reduce it to the half of its present strength."

In the United States no experiments have, I believe, been made to determine the comparative wear of the two kinds of rails; but, so far as my personal observation extends, I should have assumed a proportion at least as great as that deduced from experiments by Mr. Wood.

Having shown what authority may be adduced in proof of the statement that cast-iron rails wear much more rapidly than rolled ones, (a fact which some of the advocates for the cast rail refuse to admit,) I shall close this paper without entering into any calculations of the comparative outlays attending the wear of the two materials. These, any engineer may make for himself in a few minutes, having the foregoing data, and the cost of cast and rolled iron at the time and place where they are required to be used.

I have been induced hastily to throw together these few remarks on this important subject, in order to rectify an erroneous impression that has arisen from my recommendation of a cast-iron rail in one particular instance, that, therefore, I considered it preferable to the rolled rail in all cases.

## *Memoir upon the Stability of Revetments, and of their Foundations. By* M. Poncelet, *Chef de Bataillon du Génie. Translated from* "No. 13 *du Mémorial de l'Officier du Génie,*" *by Captain* John Sanders, *Corps of Engineers.*

[CONTINUED FROM VOL. V, PAGE 371.]

### *Upon the origin of the practical rules for calculating the thickness of retaining walls.*

84. The year 1687 is the date usually assigned to the official transmission of the general profile of Vauban to the various fortresses, though it is quite probable that it was some years sooner. It was only four years later, in 1691, that Bullet, in his *Traité d'architecture pratique*, proposed a rule, not based upon the results of experience, but upon a mechanical theory, which, although very imperfect, nevertheless appears, from the celebrity of the author, and the great number of editions of his book, to have been adopted by many architects and constructors. This rule is equivalent to taking the thickness of vertical terrace walls about equal to the 0.35 of the height, and is based upon the supposition of the earth and masonry being of the same density.

85. In a manuscript memoir of 1716, dated at Metz, and which is to be found in the *Dépot des fortifications*, Buchotte, a military engineer, supposes the natural slope of earth to be 45°, and its specific gravity to be equal to two-thirds of that of masonry; which leads him, by a train of reasoning confined solely to the hypothesis of sliding, and of a coefficient of friction equal to unity, to make the weight of the wall, which was supposed vertical, equal to two-thirds of that of a prism which answers to the natural slope of the earth; or, which amounts to about the same thing, to make the thickness of this wall equal to one-third of its height. Querlongue, in another manuscript note of 1743, has, nevertheless, observed that this rule (of one-third of the height) was only applicable to *mean* earth and masonry, and that the proportion should change with the ratio of the densities. This, however, did not hinder several following engineers, and Gauthey among the number, who, in 1785, undertook to establish the uniform correctness and generality of this same rule.

86. From the estimation justly given to his other works, and by the results of the experiments with which he has accompanied his theoretical views in a memoir published at the time designated, Gauthey has especially contributed to cause this rule to be considered as one of universal application, whether as to the effects of sliding, or as to those of rotation. For if, on the one hand, he takes the density of the earth equal to four-fifths of that of the masonry, which may be considered as a limit; on the other hand, he admits in principle, from the result of experiments erroneously interpreted, that the thrust from the pressure of the earth is independent of the angle of its natural slope, and is nearly equal to the fourth, or third, of the weight of the prism at 45°, which we may look upon as establishing a sort of com-

pensation of errors. But, to show how very erroneous similar results, formed into practical rules, must be; and, at the same time, to undeceive those engineers who still oppose the adoption of the new theories which emanate from the learned researches of Coulomb, it will suffice to remark, that, according to the spirit of the empirical rules under consideration, the resistance of a vertical wall, where the retained earth was not embanked above its top, would only exceed by a tenth, or would even simply equal, the action of the pressure of the earth—evidently an absurd consequence.

What it is here essential to be established, is—1°. That the rule of the thickness being equal to one-third of the height, originated in imperfect theories, and not from a clear and judicious experience;—2°. That it is defective; and, above all, errs in this, that it overlooks the actually given quantities on which a correct solution of the question must depend (24).

87. We have not referred to Belidor, because his method, although founded upon a more advanced theory, but equally questionable in principle, has never been generally adopted as a practical rule by engineers. But, as to that of Vauban, relative to revetments, or to demi-revetments, the opinion that it was principally founded upon military and practical considerations, without reference to any mechanical theory, being quite generally entertained; we think that we should here establish the contrary, and, at the same time, show what are the principles which might have guided the author in the discovery of his rule, which is often criticised, but seldom deviated from in practice.

Vauban, in his *Traité de la Defénse des Places*, after treating of the various masonry revetments, adds: "Moreover, we should not expect a great resistance from these revetments, for they are not made with the view of resisting cannon for any length of time, as many seem to imagine, but to sustain the rampart, and to prevent an escalade, since it is certain that, if a battery of eight or ten pieces is placed upon the parapet of a covered way, with the design of making a breach in the face of the opposite bastion, and if it is well served, then, in less than forty-eight hours, it would open this face to its foundation, and would penetrate to the earth beyond it, and, however solid the revetment might be, it would overturn it," &c.

It is thus very clear that Vauban attached no military importance to the use of counterforts; and this result, derived from a long experience in sieges, has, since then, been fully confirmed by the recent experiments made at Metz, under the direction of Captain Piobert, of the artillery. A summary of these experiments will be found in his *Traité d'Artillerie théorique et pratique*. Indeed, we see, from them, if the counterforts should remain standing, by being in part engaged in the earth, after the fall of the wall, and should thus contribute to retain the earth, that it would only require some volleys of shot and shell to overthrow this earth entirely, and thereby to lessen the slope so as to render it practicable for the assaulting party. This fact, at the same time, proves that profiles, with long counterforts, and with relieving arches, either horizontal or vertical, do not possess the military advantages that writers have erroneously attributed to them, from the commencement of the last century.

But Vauban is still more explicit in the instructions with which he accompanied his general profile, wherein he says: "This profile is accommodated to various heights of walls, is proportioned with reference to the weight of earth which they have to retain, and has been tested in the building of more than four million cubic yards (500,000 *toises cubes*) of masonry, at 150 different fortresses:" a phrase which evidently proves that this same profile was not simply the result of a long practice, but rather the consequence of rules and principles which must have preceded its application in military constructions.

Finally, the last article of these instructions being as follows, "these profiles are only proposed for masonry which has to sustain great weights of newly embanked earth, and not for that which is built against the face of an excavation where the earth has never been moved, which is generally the case with the revetments of ditches of fortifications," &c., we should conclude from it, that, under such circumstances, Vauban found the thickness furnished by his general rule to be too great. But this will not suffice to explain the motives which led him to reduce to four, or even to three, feet, the thickness at the top of counterscarps and gorge walls, in the place of five feet, which is given by the general profile, any more than it will, the reduction of the exterior slope to one-sixth. We must conclude, that Vauban not only had confidence in the solidity of his general profile, but that he knew how to introduce a judicious economy in constructions, when either the localities, or given quantities of the question, would authorize it.

88. With regard to the criticisms of this same profile by Buchotte, Couplet, Belidor, and all those who have since undertaken to investigate this question, they bore chiefly upon the apparent defect, in the proportions of the thickness and height, which makes the thickness of walls over ten metres high, too slight, and that of those under too great. This reproach appeared so much the better founded, as, in consequence of the false hypotheses then admitted upon the value of the pressure, and of the compensation of the errors which took place in the calculations; they obtained, as we have seen (85 and 86), proportions which corresponded with those of the general profile, for walls of the mean height of ten metres, and which they very naturally attributed to their having got into conditions bordering on a strict equilibrium. The fact is, that when we take at all into consideration the weight of the parapet, the influence of which decreases as the height increases, and also the effect of the counterforts, which, on the contrary, increases very rapidly with this height, we never arrive at any marked difference in the thickness. Besides, we ought not to be astonished that the rule of Vauban should only have received such slight changes, notwithstanding the numerous attacks of which it has been the object, as we shall show that they were not based upon correct mechanical principles.

### *Foundation of the rule of Vauban.*

89. In examining attentively the constitution of this profile for the case of ordinary parapets, we perceive distinctly therein an intention to make the thickness of the masonry, following the theory of the wedge, or inclined plane, increase proportionally to the height of the retained embankment, which is composed of a variable part equal to that of the revetment, and of a constant part depending upon the height of the parapet. Only that Vauban, instead of taking the height of the parapet simply equal to 2 or 2½ metres, has attributed a much greater value to it, doubtless with the intention of securing to the revetment an excess of stability, or thickness, independent of its proper height, and sufficient to guard against various accidents, such as temporary or permanent additional loads on the ramparts, scaling of the face of the wall, penetration of projectiles, &c.; circumstances which do not in fact change with the height of the revetment. Such an hypothesis seems very rational to us, and more conformable to the true laws of physics, than that by which some engineers of our day give an excess of stability, or thickness, to retaining walls, which, in place of being constant, increases proportionally with the height, as if the causes of destruction ought themselves to increase in this proportion.

90. At all events, it is very worthy of remark, that the idea of a constant additional load appeared natural enough for Couplet to adopt it in the "*Mémoires de l'Académie des Sciences*," of 1727, as proper to secure the necessary excess of stability to revetments; and that an anonymous author, in an unpublished memoir among the papers in the Dépôt of Fortifications, should conceive that this constant additional load might really have been the fundamental principle of the profile of Vauban. But the complicated calculations and imperfect theories of these authors, were not such as to set the matter in its true light, or to cause the consequences of it to be admitted by engineers. This principle will, on the contrary, appear nearly incontestible, at least with regard to the body of the masonry, if we compare the practical formula of numbers 23 and 38, with this, $e = 0.18\ \mathrm{H} + 1.64$ ms., which likewise represents (74), on the hypothesis of rotation, the thickness of vertical walls of the same stability with full revetment of Vauban.

In fact, if, in order to bring it to the case of strict equilibrium, we should divide the factor, 0.85, of the first of these formulas, by 1.459, the square root of the coefficient of stability 2.13, which enters implicitly into it (23); and should, moreover, suppose $f = 1$, or $\alpha = 45^\circ$, $p = \frac{2}{3} p'$ hypotheses universally adopted in the time of Vauban, it becomes

$$e = 0.2\ \mathrm{H} + 0.2\ h,$$

and gives results not perceptibly differing from those of the preceding, when we suppose that $h$ is equal to 8.2 metres for the lowest walls, and to 7.4 metres only for the higher revetments, such as 19 or 20 metres, for example; which is equivalent to taking a mean term, $h$

$=7.8$ metres, or, (in subtracting two metres for the height of the parapet,) to giving a constant additional load of earth 5.8 metres high, which corresponds to an additional thickness of masonry $0.2 \times 5.8$ m. $= 1.16$ m. This we should (according to the assumed views of Vauban) consider as necessary to secure to the body of the masonry a proper excess of stability independent of its height.

91. What is most singular in this similarity of results, is, that the value $h=7.8$ m., coincides almost rigorously with that of the point of intersection of the inner and outer faces of an ordinary scarp; and that the same coincidence, also, very nearly occurs in the case of demi-revetments, when we compare the approximate formula $e = 0.2\ (\mathrm{H}+h+5.8\ \mathrm{m.})$ with this, $e=0.18\ \mathrm{H}+0.202\ h+1.24$ m., which is obtained (74) from the transformation of the general profile of Vauban.

It is evident that such coincidences are not the result of mere chance, and that they justify the assertion, not only that Vauban determined the thickness of his revetments on the hypothesis of a constant additional load of earth of about 5.8 metres in height, but, besides, that he had recognized, through the range of ordinary practice, the correctness of the rule which makes the thickness of vertical walls, with a parapet covering their summit, sensibly proportional to the entire height of the earth to be sustained. However, as we have only, so far, had under consideration the body of the masonry of the general profile, it remains for us to show that the same things occur when we introduce the action of the counterforts in the calculation of the moment of stability; for that purpose we shall assume, with all the old engineers, that these counterforts turn in a common mass with the wall, around the outer edge of its base.

92. The extent back of the counterforts from the wall being, for ordinary revetments, expressed by $0.2\ \mathrm{H}+0.65$ m., and their width at their junction with the wall by $0.1\ \mathrm{H}+0.65$ m., which gives for that at the end $\frac{2}{3}\ (0.1\ \mathrm{H}+0.65\ \mathrm{m.})$; we find, for the general expression of the required moment, reduced to a running metre of the profile, and in supposing the thickness at the cordon to be about 1.625 metres, and that the counterforts are distributed along at distances from centre to centre:

1° of 5 metres apart, ($a'$) $0.000953\ \mathrm{H}^4+0.029296\ \mathrm{H}^3+0.40833\ \mathrm{H}^2+1.456\ \mathrm{H}$;

2° of 6 metres apart, ($b'$) $0.000794\ \mathrm{H}^4+0.026638\ \mathrm{H}^3+0.39444\ \mathrm{H}^2+1.433\ \mathrm{H}$;

formulas in which the term in $\mathrm{H}^4$, always very small with reference to the sum of the others, as long as H is less than 12 metres, is introduced because, on the one hand, Vauban has been obliged to make the width of the counterforts increase with their height, so as to secure them against rupture by a resistance which, in itself, increases with their weight; and, on the other hand, he wished to preserve an invariable distance between the axes of these counterforts.

If we should now likewise seek the moment of a vertical wall of the same height H, and of a thickness which may, in general, be expressed by the formula $e = k\,(\mathrm{H} + h)$, $k$ being a number to be determined, and $h$ continuing to represent the height of the parapet, augmented by its load of stability, we shall obtain for its expression,

$$\tfrac{1}{2}\,e^2\,\mathrm{H} = \tfrac{1}{2}\,k^2\,(\mathrm{H} + h)^2\,\mathrm{H} = \tfrac{1}{2}\,k^2\,\mathrm{H}^3 + k^2\,h\,\mathrm{H}^2 + \tfrac{1}{2}\,k^2\,h^2\,\mathrm{H},$$

in which the term in $\mathrm{H}^4$ is alone wanting.

We should not expect that the numerical coefficient of the formula $e = 0.2\,(\mathrm{H} + h)$ of number 90, would satisfy the condition, since it only refers to the stability, itself, of the mass of the masonry; therefore, in making $k = 0.2$ and $h = 7.8$ m., we obtain only, for the corresponding value of the moment,

$$0.02\,\mathrm{H}^3 + 0.32\,\mathrm{H}^2 + 1.28\,\mathrm{H}.$$

But, on the contrary, we shall make the results almost rigorously coincide, by taking $k = 0.2357$, $h = 7.2$ metres; for we shall then obtain the moment,

$$(c') \qquad 0.027798\,\mathrm{H}^3 + 0.40000\,\mathrm{H}^2 + 1.440\,\mathrm{H},$$

which is about a mean between those in question, if we omit all consideration of the term in $\mathrm{H}^4$.

93. It is, besides, easy to perceive why we do not again fall upon the height of the load, $h = 7.8$ m., of the preceding case; for the solidity of the connexion, and the economy in the expenditure, having brought about the giving to counterforts a thickness which increases with the height, it has also been necessary, as is shown by the drawings of the *tracé* of the general profile, that the planes passing through the edges of their bases should converge at less heights above the summit, than that which belongs to the scarp itself, so as to lessen the influence of the term in $\mathrm{H}^4$, which, in the expression of the moments, arises from this increase of thickness.

Nevertheless, if this explanation is not satisfactory, and it is desired that we should confine ourselves to the values $h = 7.8$ metres, and $k = 0.2357$, we shall find for the moment of a vertical wall, whose thickness $e = 0.2357\,(\mathrm{H} + 7.8\ \mathrm{m.})$,

$$(d') \qquad 0.027778\,\mathrm{H}^3 + 0.433337\,\mathrm{H}^2 + 1.690\,\mathrm{H};$$

and then it will also be necessary to admit that it entered into the views of Vauban to correct, in part, and for the mean height $\mathrm{H} = 10$ metres, the influence of the term in $\mathrm{H}^4$. We actually find, on this hypothesis, for the value of this last expression 88.00, and for those of $(a')$ and $(b')$, to which we compare it: 94.22 and 83.35 respectively.

Whichever we may adopt, the consequences to be drawn from the result remain nearly the same, with regard to the principles which must have guided Vauban in the composition of his profile for ordinary revetments.

94. As to the rule of demi-revetments, it is very naturally decided on by this consideration, that it will only be necessary in the expressions $\mathrm{E} = 0.2\,\mathrm{H} + 1.625$ metres for the thickness at the base of this profile, and in $0.1\,\mathrm{H} + 0.65$ m., $0.2\,\mathrm{H} + 0.65$ m., &c., for the horizontal

dimensions of its counterforts, to replace H by $H + h - 2$ m., in order to obtain the corresponding dimensions of a demi-revetment of any height H whatever, surmounted by a parapet of earth, of a mean and effective height $h$ above the cordon. For, in likewise making this substitution in the analytical expressions of the moments ($a'$), ($b'$) and ($c'$), or ($d'$), which renders them applicable to demi-revetments with the outer face either inclined, or vertical, they will continue to correspond together to the same degree of approximation. A result evident in itself, as soon as we admit, for vertical demi-revetments, the approximate rule

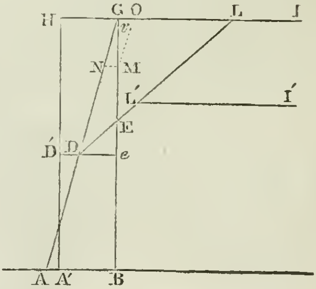
$$(e') \qquad e = 0.2357\ (H + h + 5.5 \text{ m.}),$$

5.5 m. here representing the mean additional load requisite for stability.

These approximations would be sufficient to prove, rigorously, that the rule of Vauban belongs to a more advanced mechanical theory than that of the authors who have endeavored to criticise it. But I shall endeavor to put it in a still clearer light, and to trace even the train of ideas by which Vauban might have arrived at it.

### *Principles admitted by Vauban in the establishment of his general profile, and their consequences.*

95. Let A'BGH be a vertical wall retaining the terrace BGI, on a level with its summit; from the principle of the wedge, or inclined plane, the pressure upon any height GM whatever, or the horizontal effort necessary to retain the weight of the prism of earth GMO upon the slope OM, which is at any angle $v$ whatever from a vertical, will be, in neglecting friction,



$$p \times \text{GMO}\ \frac{\text{GO}}{\text{GM}} = \tfrac{1}{2} p + \overline{\text{GO}}^2 = \tfrac{1}{2} p \text{ tang.}^2\, v \times \overline{\text{GM}}^2;$$

which demonstrates that the pressure increases, as in liquids, proportionally to the square of the height GM, and that all the difference is simply in the factor tang.$^2$ $v$, which, in liquids, becomes unity.

This single consideration was enough to satisfy Vauban, 1°, That the centre of the pressure is at about one-third of the height GM of the prism, measured from the point M; 2°, That the triangular form ABG of the profile of masonry, is that which secures the equilibrium of every part GMN, whether for the case of rotation, or of that of sliding; 3° and lastly, That the angle GMO or $v$ of the prism of pressure, could be neither zero, which is evident, nor an angle of 45°, that assumed as the natural slope of mean earth, since it would reproduce the hypothesis of fluidity, for which likewise tang. $v = 1$, but rather an intermediate angle, a half for example, or such that $GO = \frac{1}{2} GM$, tang. $v = \frac{1}{2}$; which Belidor, as far back as 1729, trusting to reason and the results of experience, desired to make it.

According to that, if we consider the equilibrium of any triangle ABG of masonry whatever, under the action of the pressure $\frac{1}{2} p$ tang.$^2 v \times \overline{BG}^2$, acting against the whole extent of its height, we shall especially obtain, on the hypothesis of rotation,

$$p' \tfrac{1}{2} AB \times BG \times \tfrac{2}{3} AB = \tfrac{1}{2} p \text{ tang.}^2 v \times \overline{BG}^2 \times \tfrac{1}{3} BG;$$

from whence

$$AB = \text{tang. } v \sqrt{\tfrac{1}{2} \frac{p}{p'}} \times BG.$$

Taking, with Belidor, tang. $v = \frac{1}{2}$, instead of $v = \frac{1}{2}\, 45°$, and tang. $v = 0.4142$, according to the latest and truest theories; and making moreover, $p = \frac{2}{3} p'$; this equation will give $AB = \frac{1}{2} \sqrt{\frac{1}{3}}\, BG = 0.2887\, BG$, in the place of $AB = 0.239\, BG$, which we would obtain from the second value of tang. $v$.

96. The first of these solutions giving to the wall an outer slope of nearly $\frac{3}{10}$ upon a vertical, Vauban ought not to have admitted it, although the constructions of his time offer examples of scarps with slopes of $\frac{1}{4}$; and in limiting himself to that of $\frac{2}{10}$, he has sacrificed a part of the advantages inherent to the profile of equal resistance; advantages which he has, however, regained by adopting a system of counterforts, properly distributed in order to supply that which was wanting in the moment of the wall.

Observing, now, that the ordinary form of the superincumbent mass of earth sustained by a revetment, such as ABCD, for example, is not CGI, but DELI, which takes away the pressure from along all the height GE, and renders the part above the cordon CD entirely superfluous for retaining the earth: we might suppose that Vauban, in comparing the moment of the prism of masonry CDG, with reference to the point A, to the sum of the moments of the pressure against GE, and of the prism of earth CDE, must have allowed them to be nearly equal, which comes to about the same thing as regarding the mass of masonry ABCD as being virtually in a state of equilibrium under the action of the mass of earth BELI. We could readily explain, on this hypothesis, and on that of a constant additional load for stability, which we shall represent, for example, by I′L′LI, the general disposition of the profile of ordinary revetments and demi-revetments. But a comparison between the moment of the wall ABCD, and that of this profile with its counterforts, does in no manner sustain such a suspicion; and we are forced to return to the consideration of a vertical wall, backed in with earth to a level with its summit, to discover the real motives and actual point of departure for the rule of Vauban.

97. Then let A′BGH be a rectangular profile of masonry, subjected to the action of the pressure of earth along its whole height BG, we shall have, for the condition of equilibrium,

$\frac{1}{2}p'\,\overline{A'B}^2 \times BG = \frac{1}{6}p \text{ tang.}^2\, v \times \overline{BG}^3$; or, $A'B = \text{tang. } v\sqrt{\frac{p}{3p'}}\, BG$;

and if we suppose, as heretofore, tang. $v = \frac{1}{2}$, $p = \frac{2}{3}p'$, we shall find $A'B = 0.2357\ BG$, which gives,

$$e = 0.2357\ (H + h)$$

$h$ designating the total height CG of the superincumbent mass of earth. For the case of sliding upon the base of the wall, we should have, ($f'$ being the coefficient of friction,)

$$f'\,p' \times A'B \times BG = \tfrac{1}{2}p, \text{tang.}^2\, v \times \overline{BG^2}, \text{or } A'B = \frac{p}{2f'p'}, \text{tang.}^2\, v \times BG.$$

In taking, as was done in the time of Vauban, $f' = \frac{1}{3}$, $p = \frac{2}{3}p'$, tang. $v = \frac{1}{2}$; this formula coincides very nearly with the preceding one. Thus, in this method, the equilibrium would also be secure on the hypothesis of the wall sliding upon its foundation.

Now, it will be observed that the former formula, when we replace $h$ in it by ($h + 5.5$ metres), coincides exactly with ($e'$) the one obtained in number 94, for the thickness of vertical revetments of the height H, which have the same stability as that of Vauban with counterforts. We can, therefore, with propriety, conclude that he had discovered, by geometrical trials made directly upon the given quantities of the problem, the kind of compensation of errors which takes place in such cases; that is to say, for a vertical revetment A'BCD', retaining a superincumbent load DLI; this compensation is between the moment of the mass of masonry CGHD', which is thrown out, and that of the triangle of earth CDE, (the weight of which is added to the wall A'BCD',) together with that which would arise from the diminution of the pressure against the whole or primitive height BG, at least as long as CG does not attain twice the height BC.

98. Although the verification of this result may be rather delicate, particularly in regard to the determination of the length of the arm of the lever of pressure, it is not a sufficient motive for believing that Vauban did not arrive at it, because this determination depends only upon the most elementary geometry. If any one doubts it, it will suffice to read the writings of the old authors, such as Belidor, who have endeavored to investigate this question in the case of loads having the form of a parapet. It will not, perhaps, be useless to remark, on this subject, that, if we adopt for the measure of the pressure of earth against a rectangular revetment A'BCD' (fig. 5), the expression $\frac{1}{2}p \text{ tang.}^2\, v \times \overline{BG}^2$, referred to the total height of the earth to be retained, and take for the reduced length of the arm of the lever of pressure, one-third of the height BC only, we would again exactly fall upon the formula $A'B = 0.236\ BG$; because that would, as above, give the equation of equilibrium, $p \times \frac{1}{2}\,\overline{A'B}^2 \times BC = \frac{1}{2}p \text{ tang.}^2\, v\overline{BG}^2 \times \frac{1}{3}BC$, or $A'B = \text{tang. } v\sqrt{\frac{p}{3p'}}\, BG$. Vauban might easily have dis-

covered that the necessary compensation takes place in the errors arising from these two hypotheses.

99. Besides, whatever may be the opinion entertained of this explanation, it will none the less be proved, that, on the hypotheses generally assumed by old engineers (75) upon the function of the counterforts, the stability of the profile of Vauban is found, as far as regards rotation, to be essentially equal to that of a vertical wall of the same height H, and with a thickness given by formula ($e'$) of no. 94. Now, this furnishes at once (72) the means of transforming this profile into an equivalent one without counterforts, and with any exterior slope whatever.

In those cases where the explanation is adopted, we must conclude from it, that, if the rule of Vauban errs in any point, it evidently does not in theory, but rather from its attributing to tang. $v$, or to $k$ (92), values 0.50 and 0.236, a little too great, which it would be more exact to replace by about 0.414 and 0.2; nor, moreover, from increasing the thickness in a proportion so much the more, as the height of the superincumbent mass ($h+5.5$ m.) is greater with reference to that of the wall; but really from depending on the hypothesis of *mean* earth and masonry.

100. Besides, if, while admitting the principle of a constant additional load for stability, in height equal to 5.5 metres, we should wish to generalize the rule of Vauban, nearly as he would himself have done it, it will suffice (97) to replace the coefficient 0.236, by the expression

$$\tfrac{1}{2}\text{ tang. }\alpha\sqrt{\frac{p}{3p'}}$$

in which we should also, for greater exactness, and in conformity with the theory of Coulomb, put tang. $\frac{1}{2}\alpha$ in the place of $\frac{1}{2}$ tang. $\alpha$.

Then we should take

$$e=\text{tang. }\tfrac{1}{2}\alpha\sqrt{\frac{p}{3p'}}\,(\text{H}+h+5.5\text{ metres}),$$

for the thickness of vertical revetments, or the thickness (72) at one-ninth of its height of a revetment, without counterforts, of the same stability, but with its outer face inclined.

But, in making use of this formula, we are to recollect, that, independently of the hypothesis of a constant additional load of 5.5 metres for stability, which, even according to the remark of Vauban (87), would not answer for counterscarps and gorge walls of military works, it will still lead (21 and 35) to an excess of thickness in the case of parapets preceded by wide berms, and in that of low demi-revetments retaining very high embankments. In such circumstances, it will tend to economy, while fully maintaining the principle of stability of Vauban, to calculate the thickness by means of equations ($s$), ($t$), ($u$), and ($s'$) of the 26th and following numbers, in which we must substitute 1 for $\delta$ and ($h+5.5$ metres) for $h$.

## *Mr. Vignoles' Lectures on Civil Engineering, at the London University College.*

[Continued from Vol. V, Page 377.]

### SECOND COURSE.—LECTURE VIII. ON CURVES.

In continution of the subject of curves, Mr. Vignoles explained that in many cases it was impracticable, or inconvenient, to apply, on particular ground, the approximate rule given in the last lecture, of setting out curves chain by chain, or other short lengths, making each the side of a regular polygon, the set-off being constant. In that method the given length was strictly a secant, and not a tangent, to the curve. Another formula was more generally applicable, and sharp curves on hill sides, through thick woods, had been quickly and accurately set on therefrom. It was this: $\mathit{offsets} = \mathit{radius} - (\mathit{radius} - \mathit{tangent})^{\frac{1}{2}}$; the demonstration of this was given, and illustrated by a diagram. For the field, tables calculated beforehand, for the greatest number of usual curves, should be prepared; but, on the occurrence of any peculiar cases, the calculation could be very readily made, with the help of a pocket table of natural sines. The Professor then recapitulated some of the leading points that had been gone over in detail at the last lecture, observing that, on the three principal expedients for counteracting the injurious effects of curves, the usual measurements might be easily remembered, viz., half an inch for the "cone" of the tread of the wheel; one inch as a *maximum* amount of "play" of the wheels between the rails, (it being disadvantageous to allow too much play;) and one inch for the extreme elevation of the outer rail in laying the way, that being the measure due to a velocity of 25 miles an hour, on a curve of half a mile radius. Mr. Vignoles then observed that the "cone" being given to the wheels on account of the curves, when the line of road was perfectly straight, this conical formation of the tyre was not required, and the general disadvantage of such a form of wheel, not bearing upon the whole face, or upper button, of the rail, preponderated. It had, therefore, become customary to incline the rail, to meet the cone of the wheel, and this should always be done, both on straight lines, and on curves whose radii are not small. This inclination of the surface of the rail is obtained by casting the receiving chair, accordingly; on rails, having a continuous bearing on longitudinal sleepers, or bearing direct on cross timbers, without the intervention of chairs, the wood is cut to the requisite angle; or the inclination is sometimes given to the rails in passing through the rolls. Without this precaution of inclining the bearing surface of the rail to meet the cone of the wheel, the edge rapidly wears, and the laminæ of iron peel off in strips, more or less, according to its quality; and there is no more critical test of the perfection of rolled iron rails, than the manner in which the button edges go through this ordeal. With the above precautions of "cone," "play," and the elevation of the outer rail, the resistances opposed by curves to a single carriage may be considered to be annihilated; but when the trains become very long, there must, of necessity, be a considerable lateral action and grinding, from the change of direction of the original drawing force through a number of carriages; but Mr. Vignoles stated that, although no conclusive experiments had been made to show the exact amount of resistance from this cause, his own observations and experience led him to conclude that the degree of curvature on railways might be safely extended further than they have hitherto been laid down on principal lines.

Mr. Vignoles referred to former observations of his, that the public would be better accommodated by more frequent departures of smaller trains, and that with such trains the curves would be of still less importance, adding that it could only be by the introduction of greater curvatures to save expense; and, as he had repeatedly argued for the same reason, by the adoption of steeper gradients, that the benefits of railway communication could be extended through many districts, and to the more distant parts of the country, as on the most economical principles of construction. Mr. Vignoles referred to the report of the Irish Railway Commissioners, and to the works of Mr. Wood, M. de Pambour, Lieut. Lecount, and other writers, for further details on curves, observing, in conclusion of this part of the subject, that where curves are so quick as to require it, especially in crossings, the additional precaution of guard rails becomes expedient.

In adding a few words on the subject of coupling carriages together in a train, the Professor insisted strongly on the draw-boys being always in the centre, and observed that, as a general rule, the connecting links should be screwed up as stiff as possible consistently with the curves of the railway, as, otherwise, the carriages are apt to swing. He mentioned that the best coupling was that of Mr. Henry Booth, the talented manager of the Liverpool and Manchester railway from its very first origin. But, as a general form of combining the draw-boys and buffers on a central rod, or tube, with spiral springs acting solely from the centre, Mr. Vignoles spoke in the strongest terms of the apparatus of Mr. Thomas F. Bergin, the manager of the Dublin and Kingstown railway, on which line they had been used with advantage for a number of years.

## LECTURE IX.—ON TUNNELS.

In proceeding to treat of the subject, which might be termed that of the great works of art, to be introduced in the formation of roads, or canals, but particularly of railways, Mr. Vignoles said that it would not be possible in the lecture room to go into the details of the construction, but that he must limit himself to general principles. The rules for consideration when such works ought to be adopted, were sufficiently simple; for example, to determine where tunnels should be substituted for open cuttings, or viaducts for embankments. The French engineers, who are in general very much better mathematicians than we are, and, probably, from that very circumstance, more inclined to be theoretical, are much in the habit of introducing formulæ, which, often very useful, are not always readily applied by the practical men of this country. Supposing it to be required to determine at what point on a longitudinal section, (for road, railway, or canal,) it is advisable to begin to tunnel, instead of continuing a simple excavation—that is, the point where it becomes as cheap to tunnel as to cut open; for such a case, the following formula is given by an eminent French engineer: Let $x$=depth of cutting; $l$=breadth of road, railway, or canal, on the traveling surface; $a$=depth of bed, of road, or railway, to be first excavated, and afterwards filled with road material, or ballast; or depth of canal below the water-line; $\frac{x}{m}$ = slope of excavation; $p$=price of the cutting per cubic yard. The expense of excavation per yard forward of the sectional area of any cutting, will consequently be $ap \times p\ (l \times \frac{x}{m} = x$; and when this price exceeds the price per lineal yard forward of tunneling, the latter is cheaper, supposing the given prices to cover all risk and contingencies in each case. But, as circumstances are continually varying, the English engineer so repeatedly finds that he has to modify—and perhaps finally abandon—the general theoretical rule, and fall back on his own experience, and that of the contractor he may be disposed to employ, that, although he may occasionally resort to such a formula as an approximation, he ceases to employ it in practice, and obtains the sectional area of the given cutting in superficial yards, by simple mensuration, and multiplies it by the price. All the complex conditions involved by slips, faults, water, and the numerous incidental occurrences in great works, to occasion unforeseen expenses, render prices uncertain, and prevent any fixed general rule; and it is only when the materials and probable contingencies are perfectly well known, that the element of cost can be safely introduced into the mathematical formula. For dry, indurated sands, gravel, sandstone rocks, &c., calculations may be made within probable limits of error; whereas, in many instances where the theoretical rule and general opinion, even of those sufficiently experienced, would recommend tunneling, it has been tried in vain, abandoned after great expense in contending with water, and recourse had, after all, to open cutting. The average cost of tunneling, upon the principal railway lines, as actually executed, appears to be about 60*l.* per yard forward, in some instances as much as 100*l.*, especially when driven forward in reckless haste, and in attempting to sink shafts, or drive drifts, without due consideration as to the quantity of water in the various strata, or the means of at once grappling with the difficulties of drainage, or pumping. With great facilities, favorable material, and not too much hurrying, the same area of tunnel has been driven for as little as 20*l.* per yard forward. In round numbers, and on an average, the sectional area of the ordinary tunnel for a double line of railway, to be worked by locomotive engines, may be called fifty superficial yards when finished, or within the ring of brickwork, or masonry, if lining were required; in this latter case, the sectional area of the opening to be excavated may be assumed as about eighty superficial yards. Mr. Vignoles observed that, for future tunnel operations, with the benefit of past errors and experience, by avoiding undue haste in execution, and with sufficient caution and activity, 40*l.* per yard forward for tunneling may be taken as an average approximate fair price. Now if it were wished to compare this expense of tunneling with the cost of open cutting, the Professor observed that, from his experience, which had been very considerable, in removing earth in large quantities, he was not disposed to put a less price than that of 1*s.* per cubic yard for removing material for deep excavations, especially when this price is to cover contingencies of slips, &c.; with such a price, then, an open cutting 55 ft. deep, roadway 24 ft. wide, and soil requiring slopes of two horizontal to one perpendicular, would give a sectional area of 800 yards—that is, the expense (in estimate) would be the same as that of tunneling. But Mr. Vignoles observed that, in addition, the future maintenance of the tunnel should be taken into consideration, as well as whether the material from the cutting could be disposed of with advantage; the nature of the soil, and a variety of other circumstances which he stated, all of which would influence the decision. In soft rock, which would work with facility, and yet stand nearly perpendicular, the depth might be very much greater than 55 ft. before tunneling would be cheaper. In such cases, a depth of 80 ft. and upwards had been resorted to. In chalk, the proper slope to be given, which was very variable, would greatly alter any elements of calculation; while, on the other hand, in forming tunnels through chalk, experience had shown that water was the great enemy, and had entailed enormous expenses. The Professor went into a great many other points for comparing excavations with tunneling, but they appeared too technical to be satisfactorily explained in a brief abstract such as this.

### *On Viaducts and Aqueducts.*

Mr. Vignoles next proceeded to the consideration of viaducts and aqueducts, into which, he observed, a totally different set of conditions enter, the cost varying from 20*l.* per lineal yard to the price for which no rule could possibly be laid down. Viaducts such as that of which the London and Greenwich railway wholly consists, may, probably, be executed for 20*l.* to 30*l.* per yard, including the foundations. Of course, the foundation entered materially into the calculation, and, where water had to be crossed, largely increased the expense. In some peculiar instances, a large river viaduct, or bridge, has cost as much as 200*l.* per lineal yard. The Professor instanced a viaduct he had built over the river Ribble, at Preston, for the North Union railway. The length was 300 yards, the height about 45 feet above the water, and the whole mass, including concrete foundations (where the rock was not attained), comprised about 25,000 cubic yards; coffer-dams were used for the piers, and for one abutment. The bridge consisted of five arches, each of 120 feet span, batiring on the face and spandrils from the parapet to the impost course—roadway about 27 feet wide; the total cost, including all contingencies, was £45,000, which is 150*l.* per yard forward, or 36*s.* per cubic yard on the whole solid contents; this might be considered a low price, inasmuch as an ordinary brick bridge, of twenty to thirty feet span only, and with facilities for construction, can seldom be built for less than 20*s.* per cubic yard. Where no water, or expensive foundations, are to be encountered, and where the spans of the brick, or stone, arches do not exceed about 60 or 70 feet, 1*s.* per cubic foot on the solid contents of the viaducts may be put as a good covering price. Mr. Vignoles stated that, for such viaducts, about 60*l.* to 70*l.* per lineal yard might probably be taken as the average approximate cost, and the additional expense, from a considerable increase of height, does not become so very great, as it chiefly affects the piers only. The Professor then enlarged much on adopting timber arches, with piers of masonry, for viaducts of large span and great height, and produced a number of drawings of such bridges, some actually constructed, and some only proposed. The heights were from 70 to 130 ft., the *minimum* price being 35*l.*, and the *maximum* 80*l.* per lineal yard. He further pointed out that high embankments should be avoided, and timber viaducts substituted, as a mere point of economy, even without taking into consideration the risk and danger of slipping in such great masses of earth. In an embankment only 40 ft. high, an occupation bridge for a farm would often cost nearly £1000; it was, therefore, only in crossing a very narrow valley or ravine, where no bridges under would be called for, and no masonry—except perhaps a culvert of the very smallest dimensions—that very high embankments should be made. Mr. Vignoles alluded to several such, varying from 70 to 90 ft. high, which he had made, and pointed out a terrible failure in one case, although in other instances success had followed. In passing through hilly countries and along mountain sides torn by ravines, the introduction of the timber-top viaduct, with stone piers, to overcome points of great but partial difficulty, was strongly recommended, especially as great additional height of viaduct could be given at small expense, and thus excavations on each side saved.

### LECTURE X.—ON THE UPPER WORKS OF RAILWAYS.

This lecture was on the upper works of railways, which term, the Professor stated, was intended to comprehend every thing above the bed, or formation level, of the roadway—viz., the gravel, broken stone, or other road material, technically called the "ballasting;" the stone blocks, or wooden cross sleepers, laid thereon; the chairs and rails, and their fastenings, as attached to the stone, or timber, supports; and the boxing, or filling up, of the road material around these supports, when the railway is finally laid to the proper gauge, range, and level—the whole of the materials and adjustment forming the "upper works"—an expression borrowed from the German *oberwerke.* The depth from the road-bed to the level of the rails, of all these parts, as permanently laid together, is seldom less than two feet, when a good way is to be insured; the principle to be observed being to have the ballasting of such a material and nature that water will percolate freely through, as clean gravel, cinders, quarry rubbish, coarse sand, &c. The word "ballast" is a northern provincial term.

Some of the first railways were introduced into the vicinity of Newcastle-upon-Tyne, Shields, and the neighboring coal shipping ports, and it being found necessary to have a bed, or layer, of some material to receive the railway track, the same not to be retentive of water; the gravel brought by the colliers from London as ballast, and accumulated in hills, or spoil-banks, near the sides of the harbors, was found to answer the purpose very well; the expression has since become common for whatever other material was similarly used for laying railroads. Mr. Vignoles observed that a great number of other technical words, now in common use when treating on railway works, were provincial terms, chiefly from the north of England. When the bottom of cuttings, or top of embankments, is of soft material, it was recommended to make a kind of pavement, or hard layer, on the forming level, below the ballast. On embankments, until they became well consolidated, this pavement would not, perhaps, be conveniently put in; still, means should be contrived to carry off the water quickly from the surface; and the Professor insisted much on the free introduction of blind, or French, drains, of broken stone, among, or under, the ballast, connected with the open side drains, which should never be omitted in cuttings; on embankments, these cross rubble drains should go free of the road-bed, with water channels down the slopes, of sods, or more substantially formed if needful.

The bed of the railway having been prepared on the above principles, next came the consideration of the railway itself. The substance first used for this trackway was wood, and afterwards a metal rail plated on the wood; after 200 years' trial of different systems—for so long was it since the first colliery wagon-ways were introduced—the Professor observed, we are just coming back to the original form and material as best adapted for the purposes of a railway, viz. timber laid longitudinally. When blocks of stone are used to support the chair and rail, weight seems to be sought for as desirable, and the general cubic contents of such blocks as are considered proper for a good way are about five cubic feet, viz., 27 inches wide, and a foot thick. When cross bearers of wood are the supports, each sleeper, as it is termed, contains about two cubic feet of timber, being about seven feet long, with a transverse section of 40 square inches, being full eight inches broad, and averaging five inches thick. The intervals at which the blocks, or sleepers, are placed, vary from three to five feet, according to the weight of the rail, or of the load. With these descriptions of support, it becomes generally necessary that a chair, or saddle, be attached thereto, to receive the rail, which is seldom fastened directly either on block or sleeper, without the intervention of this contrivance of a chair, unless when the rail is made wide and flat at the base. Such shaped rail is now much used in cross bearers of wood for temporary railways, by contractors, when executing works. Mr. Vignoles said this form of wrought-iron rail was first introduced, nearly twelve years since, on the St. Helen's railway, by some contractors, at his suggestion; and the same rails were lately in use by the same persons, and still good and serviceable after continued use. Of late it had been recommended by many engineers—among which Mr. Vignoles believed he was among the first —to lay down the railway bars on bearings of timber, disposed lengthways in the direction of the way, and upon which the iron had a continuous bearing, instead of having it supported at intervals (either with or without chairs), as was the case when blocks, or cross timber bearings, were used. In describing the different modes of laying rails, the Professor observed that the heavy stone blocks being packed around, or boxed up, with ballast, kept the rails in place—that the cross sleeper having both rails attached thereto, the gauge, or breadth, was preserved; with the longitudinal system of bearings, the parallelism was retained by cross ties of wood, with tenons, and sometimes by rods of iron with screw-ends and nuts, and occasionally with both. It was necessary thus to provide for preserving the breadth of the railway, for, as the carriages and engines work along the rails with a wriggling motion, there is always a tendency, by the lateral action of the flanches of the wheels, to push the road out of gauge. Mr. Vignoles mentioned the two new lines added on the south side of the London and Greenwich railway, as the latest examples of longitudinal timber bearings; but he observed that, as the great point in this system was to insure that the rail be firmly attached to the wood, to prevent any vertical play, he considered a more effectual method might have been there used, so as to have the iron continually united to the timber, on a plan which he had tried with success, and to which he would presently advert. When iron was first introduced for railways, it was for a long time merely a plating of metal on the edge of the wood rail, on which plan, with iron bars of greater or less weight, many of the lines in America had been laid. Cast-iron being next introduced, the system of fastenings was necessarily changed, and the original longitudinal timbers abandoned for cross sleepers, or isolated stone blocks. The rails being cast in lengths of three or four feet, it was found expedient to prepare some contrivances to receive and fasten the ends together; and this was the saddle, or chair. Some of these iron rails were cast deeper in the middle, and, from their shape, got to be termed "fish-bellied," this form being probably adopted with the idea of obtaining uniform strength; though, for railway purposes, the position of this increased depth was the reverse of that given to bearers intended to resist quiescent weights. From the action of the moving weight, however, upon rails with so many joints, they soon got out of order. Wrought iron was then introduced, to get greater lengths; the first of these were rolled, at a considerable expense of useless ingenuity, into the same form as the fish-bellied cast-iron rails, the length of 15 to 18 feet being divided into five or six flat ellipses. On most of the lines where this description of rails was first laid, it has been found necessary to take them up, and replace them, as they were found to break at a short distance from the points of support. Mr. Vignoles stated that he had, from the first, decidedly set his face against this form of rail, and argued for and introduced rails with the same section throughout their length—since commonly styled *parallel rails*, as distinguished from the "fish-bellied rail," adding 10 lb. to the original weight of 35 lb. to the yard, by putting on a lower rib, or web, on the principle that such gave additional stiffness to all beams; this lower web was increased in size from time to time, until, in a special report to the London and Birmingham Railway Co., Mr. Vignoles recommended that the upper and lower webs, or buttons, should be made precisely alike, to allow the rail to be turned up or down, or in either direction. This form was, however, first actually laid down by him on the North Union railway, and its advantages in the above respects have already been appreciated and applied; these rails are about 65 lb. to the yard. The Birmingham Company decided, finally, on adopting this form, increasing the weight to 75 lb.; and, where chairs are used, it is now almost exclusively employed, the weight being sometimes increased to 78 or 80 lb. per yard. With the increase in the weight of the rail, the intervals between the supports also gradually increased from three to five feet, but with bad effect, as the expense of keeping a railway in order with the longer bearings (as the technical phrase is) was very much augmented; and, on the London and Birmingham railway, intermediate supports had since been introduced, where the original bearings were five feet. Mr. Vignoles stated it as his opinion, deduced from considerable experience and observation, that, where chairs and supports at intervals were used, he considered a 60 lb. rail, with a 3-feet bearing, better than a heavier rail with a longer bearing. Blocks, he observed, were, however, nearly exploded as supports; the cross sleepers and chairs were still preferred by many engineers; but it was certain that, the closer the supports—that is, the shorter the bearings—the less the cost of maintenance; and hence the inference, which experience every where confirmed, that the continuous supports were best of all. In respect of fastening the chair to the block, or sleeper, and the rail to the chair, it was now almost universally admitted and acted upon, that compressed wood was much preferable to iron spikes, bolts, or keys. Mr. Vignoles introduced a number of drawings, and described a variety of diagrams, illustrating the various shaped rails and chairs, and modes of fastening adopted, and drew comparisons as to the advantages and cost of each. In reference to what he had before stated of the disadvantageous method hitherto pursued in fastening rails with flat bases to continuous timber bearings, by spikes, or screws, the Professor said that such a mode seldom continued to hold the rail close down to the timber, and there ensued a certain quantity of vertical play of the rail on the wood, often accompanied with a good deal of rattling; and, in the end, the head of the bolt, or spike, was absolutely jerked off. Mr. Vignoles said that the only effective fastening was that used with Evans' patent rails, which had a slit, or groove, of a dove-tail shape, (in cross section,) rolled for the whole length of the rail in the bottom; bolts, with similar shaped heads to fit, were passed into this groove, and dropped, at the necessary intervals, through holes in the longitudinal timbers; the bolt terminated in a screw, and, a washer and nut being put on by means of a spanner, the nut drew down the rail closely to the timber. Mr. Vignoles stated that he had had a considerable length of railway thus laid, which had been done some time, and the rail had remained close down on the wood without any play, or getting at all loose. He concluded this lecture by stating that, in the next, he would endeavor to draw a comparison between the modern heavy rail, and chair and fastenings, as used with cross timbers laid at intervals, and the rail and fastening, as above described, to be laid on longitudinal timbers, and having a continuous bearing thereon.

(To be continued.)

## *Major General Pasley on the recent great Mining Operations near Dover.*

[The following letter on this interesting subject appeared from Major General Pasley, Inspector General of Railways, in the Times of Monday.]

Sir—Having had frequent questions put to me in conversation respecting the great explosions near Dover, by which Round-down Cliff, an immense projecting mass of chalk in the proposed line of the South-Eastern Railway, was thrown down, I request your insertion of the following statement, in order to correct several inaccuracies in my own letter to you of the 23d of January last, which I wrote in haste, that it might appear in time to remove the impression which I found generally prevailed, that the whole operation was under my direction, but which I considered only a vague report, until I saw it quoted from an article in a paper, which quotation did not come to my knowledge until three days before the time appointed for the firing of those great mines.

To Mr. W. Cubitt, the engineer in chief of the South-Eastern railway, is justly due the merit of having conceived the idea of removing a mass of chalk rock, nearly 300 feet in length, but of still greater height, and averaging 70 feet in thickness, by simultaneous explosions of gunpowder, instead of employing laborers to scarp it away, which would probably have cost £8,000; and the merit of success also belongs to him, inasmuch as he took the most judicious measures to insure it; but, as he informed me that he never would have contradicted the reports which ascribed the entire superintendence of that great operation to me, and as he is not likely to publish anything on the subject, I am desirous not only of correcting the inaccuracies in my first letter to you, but also of supplying the omissions in the printed accounts, by noticing the useful labors of those who contributed to his success, which I have always made a point of doing, in every similar operation that has taken place under my own direction, and which I am sure that Mr. Cubitt would do if he wrote himself, as I know from the able resident and assistant engineers of the same railway, that, instead of assuming the whole merit of the works in which they have been employed under him, he has always been ready to acknowledge their services in the most liberal manner, both officially to the directors of the company, and personally in conversation, as I have witnessed myself.

The general impression that the mines near Dover were to be superintended by me, no doubt arose from its being known that Mr. Cubitt always intended to consult me, and that he would not, and did not, decide upon his plan of operation until after he had taken my opinion; and it was also known that he relied entirely upon my assistance for firing his mines simultaneously by the voltaic battery, of the use of which, as applied to mining, neither he nor his assistants had had any practical experience. Accordingly I went to Dover by his request, and introduced Lieutenant Hutchinson, of the Royal Engineers, who had been employed two summers under me in the operations against the wreck of the Royal George, and who happened, fortunately, to be on duty at that place at the time; so that I recommended him as the most proper person to superintend the firing of the proposed mines by the voltaic battery, provided that the permission of the Master-General of the Ordnance could be obtained to enable him to undertake this service, which was readily granted, on application being made to Sir George Murray by the railway company. Accompanied by this officer, I examined the drawings of Round-down Cliff, that had been prepared under the superintendence of Mr. John Wright, the resident engineer of this portion of the railway, to whom Mr. Cubitt referred me on the 10th of November last, and went with him into a drift, or small gallery, cut entirely through the cliff, and about 248 feet in length, which had originally been intended for the commencement of a tunnel through which the railway was to pass; a design that was abandoned afterwards on discovering that this part of the cliff was likely to give way sooner or later, and the plan of removing it by gunpowder was adopted in consequence. Shafts about 17 feet deep had been sunk from this gallery, and branches driven from the bottom of them further into the chalk, in order to obtain greater lines of least resistance, on the level of what would have been the bottom of the proposed tunnel, and agreeing with the position of the rails. Mr. Cubitt had previously told me, *that his rule for estimating the quantity of gunpowder for explosions in chalk was, to use half an ounce for each foot of the cubed line of least resistance.* As he talked of having charges of from 5000 to 6000 or 7000 lbs., I could not but be surprised at this unusual mode of estimating such very large charges by halves of ounces; but, on going to the spot, Mr. Wright explained the mystery by informing me that he had, by Mr. Cubitt's direction, fired four experimental mines in the course of the year, in which, having had no previous personal experience, he adopted the rule laid down by Major General Sir John Burgoyne, formerly of the Royal Engineers, and now President of the Board of Public Works in Ireland, for blasting in hard rock, which, as the line of least resistance in rock seldom exceeds a few feet, it was more convenient to determine in parts of an ounce than in pounds; and he also adopted Sir John Burgoyne's recommendation in his printed paper on blasting, by firing those mines with Bickford's fuses, which is an excellent expedient for blasts in rock, and inferior only to the voltaic battery, but such as I never would have used for mining. For example, Mr. Wright's first experimental mine, fired on the 5th of March, 1842, had a line of least resistance of 25 feet, was loaded with

500 lbs. of powder, had a tamping of 50 feet, and was fired with 100 feet of Bickford's fuses, in two lengths. His three other mines, the largest of which had a charge of 1100 lbs., were each fired by 50 feet of Bickford's fuse. It is difficult to conceive anything more tantalising than these arrangements must have been, for I calculated that 100 feet of Bickford's fuse would burn nearly an hour, and that 50 feet of the same would burn nearly half an hour, before the explosion took place. Nothing can be more teasing than such suspense. Our practice in the Royal Engineers, before we began to use the voltaic battery, was very different, as we never allowed a greater interval between the lighting of the portfire, or fuse, and the ignition of the charge, than from one to two minutes, being just enough to allow time for the officer, or non-commissioned officer, who fired the mine, to retire to a distance sufficient for his personal safety. In all his experimental mines, which were fired singly, and independent of each other, Mr. Wright found that the rule deduced by Sir John Burgoyne with great care and skill from numerous experiments tried by his direction, in order to ascertain the proper charges for blasts in hard rocks, which had heretofore been left to the discretion of the miners, or quarrymen, and which, in practice, seldom exceed a few ounces, were equally appropriate for mining in solid chalk; in which the charges, calculated according to the above rule, produced moderate demolition, without throwing the fragments to a distance—an object always desirable, except in military mines, having not merely demolition, but destruction, in view.

After having had this matter explained, I again inspected the plans and sections of Round-down Cliff, and, considering the length of the gallery and the proposed lines of least resistance, two of which were to be about 56 feet, I was of opinion, from my own repeated experience in conjunct mines, which had not as yet been attempted by the engineers of the South-Eastern railway, that two mines only, with charges calculated to effect moderate demolition, could not possibly throw down the whole of the cliff. I therefore approved of three charges, to be placed at equal distances from each other, but the two extreme charges to be nearer to the ends of the gallery than to the intermediate charge in the centre of it; and as I thought that Sir John Burgoyne's formula must be calculated rather for very moderate, than for moderate, demolition, I was of opinion that the distances between the three charges should be somewhat less than two-lined intervals, which our own experiments on conjunct mines had established as the most proper for moderate demolition. In case of using three charges, Mr. Wright informed me that, whilst the line of least resistance of each of the two extreme mines would be 56 feet, that of an intermediate mine between these two would be about 62 feet, which lines required two charges of about 5,500 lbs., and one of 7,500 lbs., if calculated according to the above formula, without reference to their distances apart. This last point had not yet come under the consideration of the engineers of the South-Eastern Railway, who had only fired single and independent mines, as was before observed.

On giving my opinion first to Mr. Wright, and to Mr. Hodges, his assistant, and afterwards to Mr. Cubitt, the latter objected, and, as I admitted, on good grounds, to the extreme mines being moved nearer to the ends of the gallery, although this arrangement had been adopted by me with perfect success in all my conjunct mines, because he apprehended that this would cause the fragments from those two mines to be thrown out laterally on each side of the Round-down Cliff, in the direction of the gallery, prolonged so as to obstruct the proposed line of railway, more than if the whole were projected forward towards the sea. At the time when this conference took place, I did not know how many mines were prepared, as I had only gone down one shaft, and into one chamber, to examine, but did not walk through the whole of the gallery, so that the impression upon my mind was that three chambers were then in readiness for the explosion, which was confirmed by my afterwards hearing that three charges corresponding with the lines of resistance then mentioned to me, had actually been adopted; and, therefore, when I wrote to you on the 23d of January, it was natural for me to believe, not only that every arrangement had then been previously fixed by Mr. Cubitt, subject to my approval, but that all the three chambers were actually ready for receiving the gunpowder, and only waited for the voltaic apparatus, which had all to be made, as I recommended, in preference to borrowing.

I have since been informed by Lieutenant Hutchinson, that I was so far mistaken, that only two chambers were prepared at that time, so that the third shaft, with the branch and chamber leading from it, were excavated subsequently to my visit to Dover; and also that the position of one of the first two chambers was altered after the same period. Eventually the three chambers were placed at only 70 feet apart, thus dividing the length of the gallery into four equal parts; but the line of least resistance of the central chamber, on placing them all in the same allinement, proved to be 72 feet, which would have required a charge of nearly 11,700 lbs., according to Sir J. Burgoyne's formula; and yet the original quantity of powder calculated for 62 feet was not altered. These arrangements were thus definitively made, not before, but after, my visit to Dover, at the suggestion of Lieut. Hutchinson, after he (by permission of Sir G. Murray) had been placed in charge of the proposed mines; and were very judicious, because the chambers, being only 70 feet apart, were at much less than two lined intervals, even in reference to the shortest of the lines of least resistance (56 feet) above mentioned; and, in this case, if the central charge had been estimated according to the same formula as the others, violent demolition would have been produced, which was not desirable. In short, the same rule invariably adopted by us in the royal engineer department, in respect to conjunct mines, was here followed—namely, to diminish the regular charges, which are known to be capable of effecting moderate demolition, whenever they are placed at much less than two-lined intervals apart. Though this term is very generally understood, yet, perhaps, it may not be superfluous here to explain, that, in speaking of conjunct mines, the term "two-lined intervals" implies that the central distance between adjacent charges is twice the line of least resistance of each, the latter being the distance from the charge to the nearest surface of the rock, or mass, that is to be removed by the explosion.

The whole of the arrangements for firing these great charges by the voltaic battery, were made by Lieutenant Hutchinson, assisted by Lance Corporal John Rae and private Thomas Smith, of the Royal Sappers and Miners, and by two naval pensioners, John Leary, a blacksmith, capable also of working in tin or copper, and William Gordon, a rigger; all of whom had been employed under the same officer at Spithead, and who, in their several capacities, understood thoroughly every thing relating to the preparation of charges, and to the mode of firing them by the voltaic battery. Leary, who is an excellent workman, and who distinguished himself, some years ago, whilst under the command of Captain Dickenson of the Royal Navy, by converting ships' tanks into a diving-bell, by means of which that enterprising and intelligent officer recovered the treasure sunk in the Thetis frigate on the coast of Brazil, was employed, on his arrival at Dover, in making voltaic batteries for the proposed explosions, nine in number, each consisting of six cells of Professor Daniell's constant battery, such as had been used by me in all my mining operations; and he also put together the wires for three conducting apparatus, each 1000 feet in length, and, consequently, composed of 3000 feet of copper wire. Each apparatus consisted of a pair of wires attached to a strong rope, and secured and insulated by Pensioner Gordon in the same substantial manner that had been adopted by us at Spithead; for, though there was little necessity for guarding against the action of water, yet the letting it down and dragging it up the high chalk cliffs, exposed this apparatus to a good deal of wear and tear; and it might also have been injured by the hob-nailed shoes of railway laborers, to which it was continually exposed, as I observed particularly on the day it was used, when every person that came near it trod upon it, and which, had it not been thus protected, might have destroyed the connexion, and prevented the explosion, of which I have known instances in the course of our former experiments. As soon as the batteries and conducting apparatus were complete, Lt. Hutchinson tried experiments to ascertain whether he could fire all the three charges simultaneously by one powerful battery, *as had been done by Dr. Hare, of Philadelphia, who first applied voltaic electricity to practical purposes, by using it for blasts in rocks, to obtain stone for building, in* 1831; as minutely described in Silliman's American Journal of Science, vol. xxvi, page 352, and also briefly noticed in the transactions of the British Association for the Advancement of Science, held in Bristol in 1836. From his own experiments, tried with this object, Lieut. Hutchinson drew the same inference that I had done about three years before—namely, that one cannot depend upon more than two charges exploding simultaneously, for though, by a battery of extraordinary power, he succeeded in firing twelve small experimental charges at the distance proposed for the great mines under his direction, yet there was a perceptible interval of time between the reports, which resembled a volley of musketry rather than the discharge of a single gun. He therefore determined to adopt the plan I had proposed to use in 1839, had it proved advisable to fire four subaqueous charges simultaneously against the Royal George—namely, to have a separate voltaic battery for every charge, and a person at each, with one conducting wire fixed to a pole of the battery, and the other in his hand ready to complete the circuit, according to the time marked by the chief, who was to give the words—*one—two—three*—with an interval of about one second between each, and then the word *fire*, which was to be the signal for completing the circuit; and by this mode I expected that the explosions would all take place simultaneously, on the principle of marking time in music. The powder in each of the three chambers prepared for the several mines at Dover, was contained in bags, placed in a large box, the former expedient having first been adopted in the practice of the Royal Engineers at Chatham; but we never used box and bags also, which I considered superfluous. As these boxes formed what may be called double cubes, Lieutenant Hutchinson very judiciously had a couple of short branches forking out from the lower extremity of each conducting apparatus, into two central points of the oblong charge. Very short and fine pieces of platina were placed, according to custom, near the closed ends of strong tin tubes fixed to the outside, and leading into the centre, of the powder boxes, in which tubes bursting charges of fine powder were introduced, surrounding the platina wires, on the same principle that had been used at Spithead, but without those extreme precautions that had been found necessary to resist the great pressure of water to which our charges there were subject.

In the course of Lieut. Hutchinson's experiments, an unforeseen difficulty occurred, owing to Daniell's batteries, which had been very promising, losing their power after the first frosts set in. This difficulty had never embarrassed us before, because, in our experiments at Chatham, we always took the battery out of a warm room, and it required a longer time to impair its power than our experiments there ever occupied; and at Spithead, where Lieut. Hutchinson first used the battery, it was generally kept in the cabin of one of our lighters; besides which, the work was only carried on during the summer months. He was therefore obliged to have a small wooden shed built for his batteries at Dover, and to keep fires lighted whilst using them, by which means he got rid of the difficulty.

I have since been informed that, in experiments tried at Calcutta, a very energetic battery lost half its power when the temperature fell from 120 to 60 degrees of Fahrenheit. When this difficulty occurred, a prejudice was naturally excited against Daniell's battery, and four very powerful plate batteries were ordered at Dover in consequence, which were made by an intelligent tradesman of that town. The trough of each of these contained 20 cells, according to Dr. Wollaston's construction, with zinc and copper plates, measuring 7 by 10 inches, the latter of which were only let down into the trough when the battery was about to be used; and these plate batteries were combined with the batteries made by Pensioner Leary as before mentioned, so that one very powerful battery, consisting of 40 plates of the common system, and of 18 cells of Daniell's constant battery, was to be used for each of the three charges. But here I must remark upon a great inaccuracy in my letter to you of the 23d of January last, in which I stated that the length of conducting wires about to be used at Dover was far greater than had ever been used by me either at Chatham, or at Spithead, instead of which the contrary was the fact; for, on referring back to the journal of our experiments at Chatham, I find that we fired an experimental charge on the 7th of July, 1839, at the distance of 1,950 feet, by 14 cells only of Daniell's constant battery, as recorded in the United Service Magazine for January, 1840; being more than twice the distance at which the great mines at Dover were afterwards fired by batteries of three times that magnitude, and at a temperature which could not have been less than that of our experiment. I said twice the distance, because the conducting apparatus for the charges at Round-down Cliff, originally each 1000 feet long, were afterwards reduced to less than 900, their former length being unnecessarily great. I thought it right to rectify this error, lest a prejudice should be excited against Daniell's constant battery by its supposed inferiority, which led to the employment of plate batteries at Dover, in addition to those of his pattern, which were first made. At the same time, I am now of opinion that the plate battery is the most convenient of the two for firing gunpowder; and the simplest that I have seen is that which is now being used by Mr. R. Davidson, of Aberdeen, in his interesting exhibition of electro-magnetic power at the Egyptian Hall, Piccadilly, which I visited lately in company with Dr. Faraday and Mr. Brand. This battery, which contains 20 cells, differs from Dr. Wollaston's in using amalgamated zinc, and in substituting plates of iron instead of copper, all the plates measuring 8 by 11 inches, and the action being produced by diluted sulphuric acid, upon the purity of which, Mr. Davidson says, the efficiency of his battery chiefly depends. On inquiring who first adopted iron plates instead of copper, Mr. Davidson assured me that he had used the former metal himself for about twenty years, but that the merit of this arrangement was disputed by Mr. Sturgeon and Mr. J. Martyn Roberts, with whom he himself had not thought proper to contest it. Dr. Faraday observed, that articles published in any public or scientific journal afforded the only genuine grounds for deciding upon priority of inventions; for the same idea might occur to several persons, and the individual who worked in private must give way to those who published. On this plea, I advise those who ascribe the merit of applying the voltaic battery to the purposes of blasting in earth, or rock, or the peculiar construction and management of the first plate battery, well calculated for this purpose, to any of our own countrymen, to refer to the documents before quoted, and they will find that they are doing an injustice to Dr. Hare, of Philadelphia. But it must not be forgotten, that Mr. William Snow Harris, of Plymouth, was prior even to Dr. Hare, having fired gunpowder by electricity in March, 1823, which he effected, to the astonishment of numerous spectators, by a common electrical machine, from the cabin of a small vessel at anchor in that port, whilst the charge was placed in another at a considerable distance, and separated from the former by the water, through which his conducting apparatus passed. But the electrical machine, though perfectly efficient, never would have superseded the common modes of firing mines, as the voltaic battery has done, because the former not only requires a much more delicate manipulation than could be expected either from civil or military miners, and would be more easily broken, or deranged; but it also requires artificial heat at all times, even in summer; whereas the voltaic battery can always dispense with this very inconvenient arrangement, even in the depth of winter, except in the case of very long exposure to a low temperature, which can seldom occur.

To return from this digression to the mines near Dover. By the 26th of January, the day appointed for the explosion, all the great charges had been placed in their respective chambers, with the two small bursting charges in the centre of each, whilst the conducting apparatus were led thence, two out of the east, and one out of the west, end of the gallery, to the summit of the cliff, about 300 yards beyond the edge of which they were united with their respective batteries. These were placed alongside of one another in the shed before mentioned, in which powerful charcoal fires were kept burning, one near each battery. The mines had been tamped by filling up the branches and shafts, and ten feet of gallery on each side of the shafts with rammed chalk, but leaving a vacant space of several cubic feet at each chamber, which had not usually been done by me, as my first experiment left me in doubt whether any advantage was obtained from this arrangement. Before the hour appointed for the explosion, the three voltaic batteries, each consisting, as before mentioned, of 40 sets of Wollaston plates and 18 of Daniell's, had been got ready by Lieut. Hutchinson, assisted by Lance Corporal Rae and Private Smith, who had been specially employed under him all last summer in preparing and firing the numerous subaqueous explosions at Spithead. Mr. Wright and Mr. Hodges, who had been present at, and assisted Lieut. Hutchinson in, his preliminary experiments, were now each stationed at one battery in readiness, whilst that officer himself took post at the third, to give the word of command.

The position of the spectators, and the signals for firing, &c., have been so well described by our own reporter, as well as by Sir John Herschell, in the Athenæum, and in other papers of the day, that I shall only remark that considerable anxiety was caused by the unexpectedly long intervals that elapsed between the first and second signals, which led the spectators to apprehend that something had gone wrong, or been forgotten. At last, the second signal was made, and the third signal for firing followed at the appointed interval. At this moment, the lower part of the cliff was seen to swell, or bulge, out, immediately after which the top of it descended gradually, whilst the bottom also was put in motion, and flowed slowly towards, and into, the sea, spreading out, at the same time, to more than its original width; and as it approached and filled up part of the water, a black margin was observed issuing from the extreme outline of this extraordinary stream of white chalk, which was at the time apparently in a fluid state. No smoke was perceived anywhere, unless the dark border, of which no trace remained afterwards, was such. I neither heard a report, nor felt a shock, myself, nor had I anticipated any, from the small quantities of powder used—that is, comparatively small, in reference to the depth at which the charges were buried; but the former was perceptible to many of the spectators of more acute hearing, and the latter was felt also, and described as a slight tremulous motion of the earth, by some of them. It was particularly noticed by those who were seated on the ground near me, at a high point of the cliff to the westward, which commanded a flanking view of Round-down. I would have preferred standing much nearer, and indeed a person at the distance of fifty yards from the edge of Round-down Cliff itself would have been perfectly safe, but it was impossible to have a good view except from a distance. Lieut. Hutchinson and his assistants lost the sight, and, as they felt no shock and heard no explosion, they were not without some apprehension that their mines had failed, until they rushed out of the battery-house, and heard the repeated cheers of the delighted spectators, amongst whom the hardy railway laborers, who are chiefly men of Kent, were not the least vociferous. The cause of the delay between the first and second signals was now explained to me by Lieut. Hutchinson. One of the three batteries, when tested by the voltameter, proved inactive, and, therefore, there was reason to fear that the conducting apparatus of one charge might have been deranged. But, on a closer investigation, it was found that a zinc rod in one of Daniell's batteries had broken by some accident; at which I was less surprised, because I had previously remarked on the very bad quality of the zinc, supplied from London, of which these rods had been made. On discovering this defect, that battery, consisting of six cells, was set aside, and the connexion was made by the remaining twelve, combined, as before stated, with forty sets of Wollaston plates—a power of battery even then far exceeding what was absolutely necessary; but it is best, on great occasions, to employ a superfluity of power, as I myself have always done.

Soon after the sort of volcanic movement caused by the explosion had come to an end, we observed from the top a great number of spectators, who had stood below at a respectful distance from the foot of the cliff, but who now ran and spread themselves over the masses of chalk that had been moved towards the sea, and covered a large space of ground. These persons appeared like pigmies from the high and distant point whence we viewed them; and the moving stream of chalk which flowed towards the sea, when seen from the same point, had previously appeared as if it had been crumbled into white powder, for no part of it seemed larger than the usual size of beach shingle, and the inequalities on its surface were imperceptible; but, on descending the cliff and examining the *debris*, we were surprised to find that they consisted of large irregular fragments of all sizes, some of which must have weighed more than a ton, and which were heaped up, or packed, on some places, to the height of about thirty feet, but more spread out in others.

Here and there we found fragments of earth and grass that had originally covered the top of the cliff, lying upon those rugged masses of chalk below, which, when seen from above, had appeared like dark brown spots on a white ground. As it was extremely troublesome and fatiguing to walk over the *debris*, for the smaller lumps of chalk rolled under the foot, and the larger ones could not be ascended or passed without an effort, several persons went down to the beach in order to go entirely round them, it being then low water, in which they afforded some merriment by sinking up to their middle, or falling down in crossing some little quagmires of very fine chalk and mud, with small temporary streams flowing through them from the bottom of those great masses, which had prevented the whole of the water of which they took the place from escaping quickly as the tide fell. A flagstaff had been placed at the summit of the cliff before the explosion, which was found prostrate, but uninjured, at some distance from the bottom of it, and was set up again, with a flag of the same color, on the spot, by the railway laborers. I observed a considerable portion of the voltaic conducting apparatus, which had also been thrown down; when afterwards collected and opened, for very little of it was lost, the copper wires were found to be much injured by the kinks occasioned in its fall, but externally it had appeared perfect. That the ruins of the chalk cliff thrown down by this great explosion should have covered fifteen acres of ground, may appear surprising, or even incredible, to many, as, from recollection, it did to me, until I was assured that an accurate survey of it had been made by Mr. Hodges, of which such was the result. The new face of the cliff produced by these great mines was nearly parallel to the original slope, but of a more regular form, being nearly a plane surface, except at the bottom, where a proportion of small chalk rubbish, brought down by the explosion, is piled, at a greater slope, against that which still remains solid.

Gratified, as they could not fail to be, by the splendid results of an operation that probably did not save less than £7,000, the Chairman and Directors of the South-Eastern Railway Company addressed a letter of thanks to the Master-General and Board of Ordnance, on the 16th of February, "for having allowed Lieut. Hutchinson, of the Royal Engineers, assisted by Lance Corporal Rae and Private Smith, to make the arrangements for, and superintend the firing of, the great mines at Dover, on the 26th of January, by which the entire removal of Round-down Cliff was completely effected;" and further observing, "that the important operation referred to having been accomplished by the voltaic battery, with a degree of skill as gratifying to the Directors of the Company, as creditable to the talents of Lieut. Hutchinson and those acting under his directions, they solicited the permission of the Master-General and Board, that Lieut. Hutchinson might be allowed to receive from the Company a piece of plate, which the Directors were desirous of presenting him with, in token of the high estimation in which his valuable services on the memorable occasion referred to, were held by them."

This proposition having been acceded to by the Master-General and Board, "as a special case," for it is contrary to etiquette that the services rendered by an officer of the army should be noticed by any mark of approbation, except by his own superiors, if performed as a part of his military duty, or by their permission, if otherwise,—as soon as this was communicated to them through Mr. Byham, the sum of fifty guineas was expended by the Chairman and Directors of the South-Eastern Railway Company in this testimonial of their gratitude to Lieut. Hutchinson.

Finding the immense benefit of this great explosion, Mr. Wright and Mr. Hodges, by the approbation of their chief, have since fired several other mines with equal success, in the same range of chalk cliffs, by the voltaic battery, of which they acquired a thorough knowledge, as well as of the general principle by which conjunct mines ought to be regulated, whilst under Lieut. Hutchinson—viz., two mines of 750 lbs. each on the 10th, and two of 900 lbs. each on the 14th, of February; after which, on the 2d of March, they fired eight conjunct mines, all in the same line, in which they expended 6,440 lbs. of gunpowder, along a range of cliff of such very irregular outline that they varied their charges from 200 lbs. to 2000 lbs. Mr. Hodges has contrived a simple and ingenious apparatus for completing the circuit of several voltaic batteries at the same moment, by one operator; and they propose to fire more than 12,000 lbs. of powder, distributed amongst fifteen or sixteen conjunct mines, in order to remove another portion of the same cliff, on the 18th instant. In short, these gentlemen, who had no knowledge of this art a year ago, have profited so well by their opportunities, that I consider them capable of planning and executing any mining operation, however extensive, with skill and success.

In respect to conjunct mines calculated for a scale of moderate demolition, I shall here remark, that it is not absolutely necessary that they should all explode at the same moment of time, (which is difficult even by the voltaic battery, but, by all the former methods of firing gunpowder, absolutely impossible, though the contrary has been asserted by writers copying from the old French authors on military mining.) For example, in the course of our experiments at Chatham, before we knew the use of the voltaic battery, we first demolished a brick wall, about four feet thick, by blasts fired successively by a very small powder hose leading along the back of the wall, and connected with each charge, one end only of which hose was ignited. In like manner, Lieutenant (now Captain) James, of the Royal Engineers, acting under my direction, demolished 466 feet in length of the brick revetments, or retaining walls, of an entire front of the old fort of Sheerness, with the exception of one of its flanks, but including its ravelin, with such complete success, on the 14th of July, 1827, that the brickwork was, as it were, just turned over nearly on the same spot, but crumbling into pieces as it fell, without any of the fragments being thrown to a distance, although no two of the explosions were simultaneous. In this operation, 15 charges, generally of 84 lbs., but some of 90 lbs., in barrels, were used against the demibastion and curtains, whilst 23 charges of 25 lbs. each, placed in bags, were used against the ravelin. The former were grouped by twos or threes as conjunct mines; the latter were all fired one after another, at intervals of several seconds of time, by igniting one end of a longitudinal hose laid along the top of the wall, and communicating with separate vertical hoses leading down into the several charges. But though simultaneous explosion is thus evidently unnecessary in conjunct mines, having their charges calculated to effect moderate demolition —yet, in the case of violent demolition, absolute precision is indispensable, otherwise the explosion of the first charge may derange the others, and either diminish the general effect of the whole, or even cause some of them to fail altogether, of which I have known instances.

The great explosion which took place at Dover on the 26th of January last, is certainly the triumph of the art of mining in this country, but the British military engineers, by whom undoubtedly it has been brought to perfection, were not so fortunate in their first attempts as the able civil engineers of the South-Eastern Railway. Owing to the inefficient state of the Royal Engineer Department at the commencement of the present century, which was not improved until towards the close of the Peninsular war, the officers had no opportunities of acquiring practical knowledge of this important art. Hence in Sir John Moore's retreat all the mines of demolition made for the destruction of the bridges in our rear failed, excepting one, in which Lieutenant Davy, a most promising young officer, blew himself up along with the bridge that he destroyed; and I myself was one of the unsuccessful operators in that campaign, in an undertaking in which no non-commissioned officer, and very few privates of the corps would now fail. At the siege of Badajoz, Captain Stanway, a most gallant and intelligent engineer officer, succeeded in placing a charge to blow up a dam that retained an inundation, which was a great impediment to the besiegers, but the explosion failed, from the mode of securing charges against the pressure of water not being then understood; and in the attack of Burgos, the work of the British miners was obliged to be suspended from time to time, for want of air, because the simple method of ventilating military mines was not known. Towards the close of the Peninsular war, however, the distinguished engineer officers employed in it had acquired more experience, and none of their mines of demolition against bridges, &c., failed as at first.

In India, where the same defects prevailed, perhaps to a still greater extent, the first mining operations after the commencement of the present century were not merely unsuccessful, but calamitous, for at the siege of Cumoona, an insignificant little mud fort, in 1807, the company's engineer officer, whilst preparing mines to throw down the enemy's counterscarp, was himself blown up in his own gallery, by the native miners opposed to him, and our troops were afterwards repulsed with great slaughter in an attempt to storm the place, which, however, was afterwards evacuated in the night. About two years before, in the first siege of Bhurtpore by Lord Lake, the repeated assaults ordered by that gallant general had been repulsed, chiefly by explosions of gunpowder prepared in the ditch. More recently, the East India Company's Engineers have everywhere distinguished themselves by their superior skill in mining, especially at the second siege of Bhurtpore, in 1826, though the native miners there had lost nothing of their former energy, for they actually penetrated into one of our galleries, where a combat took place, in which a captain of the Engineers was wounded. Their efforts were, however, unavailing, for the Company's Engineers opened the way for our storming parties into that supposed invincible fortress by two great mines, one of which not only effected a broad and practicable breach, like the other, but leveled in the dust a large circular bastion, on which 300 or 400 of the enemy's bravest troops were posted, who were all destroyed by the explosion. I need scarcely mention that the East India Company's Engineers performed the same important service in Lord Keane's attack of Ghunzee in 1829. Failures on either of those occasions, such as had previously occurred after the beginning of the present century, would have shaken our Indian empire to its centre. In Europe and America, where the Royal Engineers only are employed, mining has not been required in any of our military operations subsequent to the close of the Peninsular war; so that they have not had the same opportunities of establishing their character for skill in mining, which their friends and contemporaries of the same branch of service in India have enjoyed.

If my first letter, which appeared in your columns of the 24th January last, had not been full of inaccuracies, I would not have troubled you either with the above account of the great mines at Dover, or with the observations on the progress of the art of mining in the British service, into which I was led in the course of my narrative, for the length of which I beg to apologize, and am, Sir,

Your most obedient servant,

C. W. Pasley, *Major-General.*

Civ. Eng. & Arch. Journ.

## Architecture.

### *Tesselated Pavements—Ancient and Modern.*

[A work has been recently published, at a great expense, under the direction of Mr. Blashfield, who is connected with the old established firm of Messrs. Wyatt, Parker & Co., the cement manufacturers, for the purpose of exhibiting to the profession what truly beautiful patterns may be adopted in tesselated and mosaic pavements, by the aid of the small porcelain squares recently introduced by Mr. Blashfield for that purpose. The work consists of ten elaborate designs by Mr. Owen Jones, the author of the "Alhambra," splendidly printed in colours. These designs cannot fail in directing the public taste to this admirable description of ornament, for the floors of halls, saloons, conservatories, baths, &c.—we may also add the aisles of churches; for to our taste, it is far preferable to the dingy encaustic tiles. The following essay on the materials and structure of tesselated pavements is by Mr. F. O. Ward, who has devoted considerable research in collecting the information.]

The object of the following notice is to call public attention to a new material for tesselated pavements, and to an improved method of constructing the same, by the adoption of which this ancient and esteemed mode of decoration may be re-introduced, at a moderate cost, for the embellishment of our modern buildings. The improvements in question will, it is confidently believed, enable the modern architect to execute mosaic floorings, equal in point of extent and elaborateness to the most celebrated of the remains that have descended to us from antiquity, and very far superior to these in brilliancy and variety of colouring, in the accurate co-adaptation of the pieces, and in the uniform durability of the surface.

In order to arrive at a just conclusion on this subject, it will be necessary in the first place to bestow some attention on the materials and structure of the old Roman tesselated pavements, as described by Vitruvius, and still to be traced in the remains existing in various parts of the country, and in the specimens preserved at the British Museum.

The materials of the best and costliest pavements at Rome (such, for example, as those still remaining in the baths of Caracalla,) are colored marbles of various kinds, differing considerably from each other in hardness and durability. The inferior pavements, found scattered through Britain, France, and other parts of Europe, and along the Northern coast of Africa, are usually made of such coloured stones as the neighborhood happened to supply, with the exception only of the red tesseræ, which are almost invariably of burnt clay. Thus, in the celebrated Roman pavement which was discovered in 1793, at Woodchester, in Gloucestershire, the gray tesseræ are of blue lyas, found in the vale of Gloucester,—the ash-coloured tesseræ of a similar kind of stone, often found in the same masses with the former, —the dark brown of a gritty stone, met with near Bristol, and in the forest of Dean,—the light brown of a hard calcareous stone, occurring at Lypiat (two miles from the site of the pavement)—and the red tesseræ, as usual, of fine brick. These materials differ from each other in point of hardness even more than the colored marbles of the costlier pavements at Rome; and it is evident that a surface composed of such heterogeneous materials must wear unequally at different parts, and ultimately fall into hollows wherever colors produced by the softer kinds of stone are employed.

If this remark should be met by a reference to remains of ancient pavements, discovered in this country after a lapse of sixteen centuries from their first construction, and still retaining a level, unworn surface, it is obvious to reply, that the mere length of their duration gives no force to the objection, seeing that, during by far the greater portion of the time, these pavements have lain buried; and, further, that even when in use they formed floors to the baths and best chambers of the residences of Roman provincial governors, and were, therefore, doubtless, subject to very inconsiderable traffic. The entrance hall of a modern club-house would afford a much more trying test of durability; and it will hardly be disputed that a pavement composed of heterogeneous materials would in such a position be liable to wear unequally.

The next point to be observed with reference to the Roman tesseræ, is the want of uniformity in their size and shape, and the consequent irregularity of their junctures, especially in the more minute portions of the design. Whoever will take the trouble to examine the choicest specimens of old pavements at the British Museum, (as, for example, one presented by Mr. Lysons, which formed part of the Woodchester pavement referred to above,) will perceive that the tesseræ, instead of coming into contact by smoothly ground and equal sides, are in many places separated by broad and uneven lines of cement. In some parts the intervals are of such width that the cement, which in a good pavement would be scarcely seen, forms at least a fourth of the visible surface. It is scarcely necessary to point out the effect which this net-work of brown cement lines, running through the whole design, and mixing a muddy hue with every tint, must have in diminishing the purity of the colors, and in deadening the sharpness and brilliancy of their contrast. It is much as if a picture, when finished, should be crossed and re-crossed all over with lines of brown paint.

Proceeding from these remarks on the materials of the Roman pavements to consider the mode of their construction, we shall find that, while the effect produced was imperfect, the means employed for its production were costly and inadequate to the end proposed.

Vitruvius, in the first chapter of his seventh book of architecture, after describing the manner in which the foundation of the pavement should be formed, goes on to say, that on the topmost layer of cement the tesseræ are to be laid—care being taken to keep the surface flat and true with the level; that, in the next place, all unevennesses and projections are to be worked down by rubbing and polishing; and that, lastly, a layer of cement is to be spread over the whole and scraped off again (in order, it would seem, to fill up any cavities in the cement between the tesseræ, and to render the surface as smooth as possible all over.)*

We need not dwell at length on the time and trouble that it must have taken to set each tesseræ separately in the cement, and to try the surface with the level after every few pieces were laid. With respect to the subsequent operation of grinding down and polishing the surface of the work, it must have been in most cases, (and particularly where stones of a hard and gritty nature were employed) the most tedious and laborious part of the process. We shall presently see that all these difficulties are obviated by the employment of the newly invented material and mode of construction, which we will next proceed to describe—taking, however, in the first place, a rapid survey of the various experiments which preceded this invention, and of the successive improvements by which it has been gradually brought to perfection.

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* This is the general sense of the passage, according to the best commentators. The phraseology in the original is here very obscure, and has probably suffered from the carelessness of early transcribers.

About forty years ago, a patent was obtained by Mr. C. Wyatt, for a mode of imitating tesselated pavements, by inlaying stone with colored cements. Floors thus constructed, however, were found liable to become uneven in use, in consequence of the unequal hardness of the materials; which defect prevented their general adoption. Terra cotta inlaid with colored cements has also been tried, and found liable to the same objection.

During the last ten years, cements colored with metallic oxides, have been used by Mr. Blashfield, to produce imitations of the ancient tesselated pavements; and, for work protected from the weather, the material appears to have answered tolerably well; but for out-door work, required to stand frost, it has been found necessary to employ Roman cement, the dark brown of which gives a dingy hue to all colors mixed with it. This, with some other practical difficulties, has interfered with the success of the plan.

Bitumen colored with metallic oxydes has also been tried by Mr. Blashfield, as a material for ornamental floorings. The groundwork of the pattern was first cast in any given color, and the interstices were afterwards filled up with bitumen of various other shades. But this method was even less successful than the former; the contraction and expansion of the bitumen soon rendered the surface uneven; the dust, trodden in, obscured the pattern; and the plan, besides being ineffectual, was expensive.

Three years ago, Mr. Blashfield succeeded in constructing an extensive and elaborate inlaid pavement, on the plan of the Venetian Pisé floors. It was made after designs furnished by H. S. Hope, Esq., at whose country-seat, Deepdine, in Surrey, it was laid down. It is still in good preservation.*

In the same year (1839) Mr. Singer, of Vauxhall, obtained a patent for a mode of forming tesseræ, by cutting, out of thin layers of clay, pieces of the required form, which are afterwards dried and baked in the usual way. His patent also included an improved method of uniting the tesseræ with cement, so as to form slabs of convenient size for paving. He has executed in this manner some very admirable mosaics, and his invention must be regarded as one of the most important steps towards the revival of the art in this country.

We now come to the discovery which led to the invention of the tesseræ particularly referred to throughout this treatise.

In 1840, Mr. Prosser, of Birmingham, discovered that if the material of porcelain (a mixture of flint and fine clay) be reduced to a dry powder, and in that state be subjected to strong pressure between steel dies, the powder is compressed into about a fourth of its bulk;

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* A floor of a very similar kind was laid down at Mr. Hope's mansion, in Duchess street, about sixty years since, and it is said to be still in excellent condition.

it then undergoes a process of semi-vitrification, and is converted into a compact solid substance, of extraordinary hardness and density; much less porous, and much harder than the common porcelain, uncompressed.

This curious, and as it has since proved, very important discovery, was first applied to the manufacture of buttons, to supersede those of mother-of-pearl, bone, &c. The buttons thus stamped out of porcelain powder are capable of resisting any pressure to which they are subject in use, and are more durable, as well as cheaper, than buttons of the materials ordinarily used.

The applicability of this ingenious process to the manufacture of tesseræ for pavements, soon afterwards occurred to Mr. Blashfield; who made arrangements with Messrs. Minton & Co., (the manufacturers appointed to work Mr. Prosser's patent,) for a supply of small cubes made according to the new process; these he submitted to various trials and experiments, and having found them in every respect suitable for the purpose, he has recently, in conjunction with Messrs. Wyatt, Parker & Co., carried out the invention on an extensive scale. Tesseræ of various colors and forms—red, blue, yellow, white, black, brown; quadrilateral, triangular, rhomboidal, hexagonal, &c.—have been manufactured on this principle in large numbers; pavements of considerable extent have already been constructed with them; and they have been found to possess the following advantages:—

First, being formed in similar steel dies, they are of uniform size and shape, so that they can be fitted together accurately in the laying down of the most complicated designs. Secondly, being all composed of the same material, variously colored, they are all of precisely equal hardness, so that pavements made with them are not liable to fall into hollows in use. Lastly, owing to the effect of the intense pressure under which they are made, they are quite impervious to moisture, of flinty texture throughout, and, in a word, to all intents and purposes absolutely imperishable.

In these several respects, their superiority to the Roman tesseræ, (which, as we have seen, were shaped imperfectly by hand, and differed from each other in hardness,) must be manifest to the reader. Nor less conspicuous is the superiority of the modern process of uniting the tesseræ to form pavements.

For this purpose (instead of spreading the cement on the surface to be paved, and laboriously setting each single tesseræ in it, according to the directions of Vitruvius,) the pavement is first put together, face downward, on a smooth surface, so that the tesseræ find their level without any trouble to the workman; and as soon as a sufficient portion of the design is finished, it is backed with fine Roman cement, which is worked in to fill the crevices between the tesseræ; the pavement is thus formed into smooth flat slabs of convenient size (according to Mr. Singer's method) and these are laid down on a foundation properly prepared in the usual way.

One peculiar feature of this process is, that private persons, if so inclined, may set out their own pavements in the colored tesseræ, leaving it for a workman afterwards to cement and lay down the slabs. Fine mosaic work for the tops of tables, for illuminated monuments, &c., may be made in the same manner with a superior kind of tesseræ, glazed on the surface, and richly ornamented in gold and colors.

Pavements thus constructed are singularly beautiful. The outline of the design strikes clearly and sharply upon the eye, and the brilliant colors of the tesseræ are reflected from the level surface, uninterrupted by those broad, uneven lines of cement, which in the Roman pavements detract so much from the general effect. The truth of every line and angle in the figure, and the just proportion of all its parts, however complicated and various, impress the mind with an agreeable sense of order and precision. Such, indeed, is the exactness and facility of the workmanship in these pavements, that the oblique and intricate intersections of the Mauresque designs are as readily executed as the simple rectangular patterns of the Pompeiian style. Even the scrolls and twisted guilloches, the quaint emblematical device, and grotesque representations of horses, warriors, &c., found in the most elaborate of the Roman pavements, may be accurately imitated with the new stamped tesseræ.

The Roman designs, however, have little to recommend them to the modern artist, beyond their historical interest. Even the earliest of them, which are the best, were produced subsequently to the Roman invasion of Greece, when art was everywhere declining; and they abound with indications of the extravagant and licentious taste which grew up amidst the general corruption of Roman manners, occasioned by the rapid influx of foreign wealth, and foreign habits of luxurious excess.

When designs after the antique are required, the elements of them should rather be sought in the beautiful decorations of the Etruscan vases, and in the admirable remains of Greek art in general, during its best period—*i. e.* from about 400 to 200 B. C. or during the time of Phidias, Praxiteles, and their immediate successors. (Such are the models which have guided the composition of the magnificent tesselated pavement designed by Mr. Barry, and executed under his direction by Mr. Singer, for the hall of the New Reform Club; a pavement so beautiful and so generally admired, that it can hardly fail to give an impulse to the re-introduction of mosaic decoration hitherto so sparingly employed by modern architects.)

For Mauresque designs, the mosaic dados of the Alhambra may be advantageously consulted. They are executed in glazed earthen tiles, variously colored, shaped with considerable exactness, and joined with cement. They present many examples of ingenious arrangement and well contrasted coloring.

But, whichever of these various styles the architect may adopt, he will find that, for the realization of his conceptions, there is no material which presents so many advantages as the compressed porcelain tesseræ—whether on account of their uniform size and shape—the purity and brilliancy of their colors—or their extreme hardness, and unalterable durability.

Civ. Eng. & Arch. Jour.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

## *On Public Cemeteries. By* JOHN C. TRAUTWINE, *Collaborator on Architecture.*

The following extracts from an article on Public Cemeteries, will doubtless prove highly acceptable to many readers of the Journal. It is selected from an able treatise on the subject, written by Mr. J. C. Loudon, of London, Conductor of the Gardener's Magazine, the Architectural Magazine, and other periodicals and architectural works, which have acquired for him, in the United States, a well merited reputation as a gentleman of refined taste, and close observation.

We have begun in this country to give the Public Cemetery system a fair trial; and the entire success, and universal satisfaction which have hitherto attended the experiment, furnish every assurance that the system will eventually become general; while the consequent desire to obtain the most authentic information on the subject, must ensure a cordial reception to a paper like the following, emanating as it does from so high a source.

The extension of the system will be attended by many important advantages to the public. Not only will it remove from our cities a source of disease, much more noxious than is generally supposed, but it will exert a powerful influence in exciting and diffusing a taste for that delightful branch of ornamental agriculture, landscape gardening, which has hitherto remained comparatively unpracticed, and, indeed, almost unknown in this country. Landscape gardening, when conducted on scientific principles, constitutes one of the most agreeable and essential accessories to the beauty of rural architecture; and when our cemetery companies possess the advantage of spots so eminently calculated for its display, as Laurel Hill, Monument Cemetery, Mount Auburn, and others, a free application of its principles cannot fail to arrest the attention of every observer endowed with a spark of natural taste, and gradually lead to its more general subserviency to architectural purposes. Hence I do not hesitate to recommend the introduction of this paper under the head of "Architecture," in the Journal of the Institute.

The erection of monuments designed on architectural principles, contrasting as they necessarily will, with those common-place designs which impart to our grave-yards an air of funereal stereotyping, must likewise aid in improving the architectural taste of the visitors. Even the less observant will perceive that the most costly and profusely decorated monuments are not necessarily the most beautiful; many will thus be led to inquire what contributes the elements of beauty in architectural design? and this inquiry will by degrees extend itself to our public buildings, until the mass of our citizens shall at length derive from the contemplation of a structure erected in conformity with strict architectural principles, some degree of that refined gratification, which is now confined to a very few.

*The Principles of Landscape-Gardening and of Landscape-Architecture applied to the laying out of Public Cemeteries and the Improvement of Churchyards; including Observations on the Working and General Management of Cemeteries and Burial-Grounds.* By J. C. LOUDON, F. L. S., H. S., &c.

The circumstance of being employed by the Directors of a Cemetery Company at Cambridge, to form a plan for their guidance in arranging the ground, and in working and managing the cemetery afterwards, led us to study the principles on which all the arrangements connected with cemeteries are, or ought to be, founded, and the following pages contain the general results of our inquiries.

### I. THE USES OF CEMETERIES.

As, to know the best mode of applying the principles of design to any particular object, it is necessary to know the purposes for which that object is intended, we shall commence by considering the *uses* for which cemeteries or burial-grounds are required.

The *main object* of a burial-ground is, the disposal of the remains of the dead in such manner as that their decomposition, and return to the earth from which they sprung, shall not prove injurious to the living; either by affecting their health, or shocking their feelings, opinions, or prejudices.

A *secondary object* is, or ought to be, the improvement of the moral sentiments and general taste of all classes, and more especially of the great masses of society.

With respect to the first and most important object, the decomposition of the dead, without the risk of injury to the living, there is, as we think, but one mode in which this can be effected, to which there can be no objection on the part of the living; and that is, interment in a wooden coffin in the free soil, in a grave 5 or 6 feet deep, rendered secure from being violated, in which no body has been deposited before, or is contemplated to be deposited thereafter.

Various circumstances, however, into which it is needless to inquire, have given rise to burying several bodies in the same grave in the free soil, and to modes of sepulture by which the decomposition of the body, or at least its union with the earth, is prevented; such as the use of leaden or iron coffins, and depositing them in vaults, catacombs, and other structures, in which they can never, humanly speaking, except in the case of some great change or convulsion, be mingled with the soil, or, in the beautiful language of Scripture, be returned to the dust from which they sprung. Though we are of opinion that the modes of burial which prevent the body from mixing with the soil, which, for the sake of distinction, we shall call the sepulchral modes, cannot, on account of the danger to the living, be continued much longer in a highly civilized country, yet, in considering the conditions requisite for a complete cemetery suited to the present time, the various modes of sepulchral burial at present in use must be kept in view. The expense of the sepulchral mode, however, confines it to the comparatively wealthy; and hence by far the greater part of burial-grounds always was, and is, necessarily, devoted to interments in the free soil. In some churchyards where there is abundance of room, only one coffin is deposited in a grave; but in most cases, and particularly in the burial-grounds of large towns, the graves are dug very deep, and several coffins, sometimes as many as a dozen, or even more, according to the depth of the grave, are deposited one over another, till they reach within 5 or 6 feet of the surface. Interments in this manner are of two kinds. The first are made in family graves, in which the different members of the same family are deposited in succession, in the order of their decease; and to such graves there is always a grave-stone or some kind of monument. The second are what are called common graves, to which there is no monument, and in which the bodies of the poor and of paupers are deposited, in the order in which they are brought to the cemetery; probably two or three in one day, or possibly as many in one day as will fill the grave. Unless this mode were adopted in the public cemeteries, they would, from their present limited extent, very soon be filled up. Such graves, whether public or private, in the newly formed cemeteries, when once filled with coffins to within 6 ft. of the surface, are understood never to be reopened; but, in the old burial-grounds, they are in many cases opened after being closed only four or five years, and sometimes much sooner.

When the parties burying cannot afford to purchase a private or family grave, the practice is, in some burial-grounds, to bury singly in graves of the ordinary depth of 6 or 7 feet, and these graves are reopened for a similar purpose in six or seven years; but, as this is attended with the disinterment of the bones, it is a very objectionable mode. In a burial-ground properly arranged and managed, a coffin, after it is once interred, should never again be exposed to view, nor a human bone be disturbed. At present this is only the case in the cemeteries of the Jews, where there is a separate grave for every coffin, and where the graves are never reopened. It is also the case in the cemeteries of the Quakers; though not, we believe, from religious principle, as in the case of the Jews, but rather from that general regard to decency and propriety which is a characteristic of that sect of Christians, and perhaps, as in the case of the Moravians, in consequence of their comparatively limited number.

As *data* to proceed upon with reference to interments in the free soil, it is necessary to state that the muscular part of the body either decays rapidly, or dries up rapidly, according to the circumstances in which it is placed; but that the bones do not decay, even under circumstances the most favorable for that purpose, for centuries.

The face of a dead body deposited in the free soil is generally destroyed in three or four months, but the thorax and abdomen undergo very little change, except in colour, till the fourth month. The last part of the muscular fibre which decays is the upper part of the thigh, which in some subjects resists putrefaction for four or five years. In general, a body is considered unfit for dissection after it has been interred eight or nine weeks. In a very dry and warm soil, especially where the body is emaciated, the juices are rapidly absorbed; and, no moisture coming near it, the solids contract and harden, and a species of mummy is produced. This may be observed in the vaults of various churches in Britain where the soil and situation are remarkably dry; and it has given rise to those appalling scenes which may be witnessed in the vaults of Bremen, Vienna, Rome, Naples, Palermo, Malta, and other places. (See *Necropolis Glasguensis*, p. 48. to 55.; and Stephens' *Incidents of Travel*, as quoted in the *Saturday Magazine*, vol. xx. p. 141.)

Bones are chiefly composed of phosphate of lime deposited in gelatine, an animal tissue; and, unless acted on by powerful acids, they will endure, either in the soil or in the atmosphere, for many centuries. They are even found in the fossil state, and after ages of exposure often contain more or less of the original animal tissue, particularly if they have been embedded in clayey soil. In the antehominal part of the creation, there are bones daily discovered which have existed 6000 years at least. Dr. Charles Loudon informs us that he has seen numerous human bones in certain caves near to Naples, which are supposed to be those of the Grecian colonists who settled there before the Christian era, or perhaps those of an older race who inhabited Magna Græcia. Dr. Loudon has seen several skeletons dug out of the ruins of Pompeii, the bones of which were as dry and entire as the bones of skeletons which we see in dissecting-rooms, though they must have lain there nearly 1800 years under the lava, which, around them, seemed to be a dry greyish kind of earth. Even while writing this, we read in the newspapers (*Morn. Chron.*, Jan. 10.) of the workmen, while digging a deep sewer in Lad Lane in the city, having cut into what is supposed to have been a cemetery of the Romans, and dug up a number of human bones.

With respect to *prejudices*, there is, as every one knows, a decided prejudice in favour of being buried in dry soil, and against the placing of decomposing substances, such as quicklime, in coffins; and it is one of our principles to respect existing prejudices as well as vested rights. With regard to the use of quicklime; independently of the existing prejudices against its introduction into coffins, it is found to cause the solution of the softer parts of the body, which, unless the coffin is watertight, and this is rarely the case with the coffins either of the poor or of the middling class, oozes out to such an extent that the undertaker's men can scarcely carry the coffin, on account of the flow of matter and the odour.

*The health of the living* is chiefly affected by a certain description of gas, respecting which it is necessary to enter into some detail. The decomposition of the muscular part of the human body takes place with different degrees of rapidity in different soils, and at different depths in the same soil. It is most rapid in sandy soils somewhat moist, within 3 or 4 feet of the surface, and in a warm climate; it is next in rapidity in chalky soils; much slower in clayey soils; and slowest of all in peaty soil, saturated with astringent moisture. In general, dry soil, and a moderate distance of 5 or 6 feet below the surface, are favorable both to decomposition and human prejudices. In such soil, in the climate of London, the muscular part of the human body will have become a black mould in between six and seven years; but, practically speaking, the bones may be considered as indestructible. In the progress of decay, the first change which takes place immediately after death, is the escape of a deleterious gas from the mouth and nostrils, but generally in so small a quantity as not to be perceptible for three or four days. In some cases, it is perceptible in a much shorter period; and in all, a gas accumulates within the body, which escapes sooner or later according to the progress of the putrescent process. If the body is buried in the free soil, in a wooden coffin, to the depth of 5 or 6 feet, the gas escapes into the soil, and is, in part at least, absorbed by it, and consequently does not contaminate the air above the surface; but, if a leaden coffin is used, and the body is deposited in a vault, catacomb, or brick grave, the gas escapes within the coffin, and either remains there till the coffin decays, or escapes through crevices in the lead, and through small holes bored on purpose by the undertaker in the outer wooden coffin and leaden inner coffin, and concealed by the name-plate. *(Report on the Health of Towns, Walker, &c.)* By the last mode the gas begins to escape before the corpse is taken from the house; and its effect is often felt there, as well as when the service is being read over it in the chapel, and even after it is deposited in a vault, the catacombs of which, though apparently hermetically sealed, are seldom air-tight. Sometimes the body, especially of a corpulent person, swells so much before it is removed from the house, that it is ready to burst both the inner and the outer coffin; and in that case it requires to be tapped, and the gas burnt as it escapes, or the operation performed close to an open window. Even in some of the public catacombs of the new London cemeteries explosions have been know to take place, and the undertaker obliged to be sent for in order to resolder the coffin; which shows the disgusting nature of this mode of interment, and its danger to the living. To inhale this gas, undiluted with atmospheric air, is instant death; and, even when much diluted, it is productive of disease which commonly ends in death, of which there is abundant evidence in Walker's *Grave-Yards*, and the Parliamentary Report quoted. The gas abounds to a fearful extent in the soil of all crowded burial-grounds, and has been proved to be more or less present in the soil thrown out of graves where bodies have been interred before. Even in the new London cemeteries, when interments are made in family graves, or common graves, which have been filled in with earth, such is the smell when the grave-diggers arrive within 2 or 3 feet of the last deposited coffin, they are obliged to be plied constantly with rum to induce them to proceed. This is more particularly the case when graves are dug in strong clay, because the gas cannot escape laterally as in a gravelly or sandy soil, but rises perpendicularly through the soil which has been moved. The remedy for this evil is, never to allow a family grave, or a common grave, in which an interment has been made, to be excavated deeper than within 6 feet of the last deposited coffin; and, to make sure of this, there ought to be a protecting stone, or slate, to be hereafter described, deposited when the grave is being filled, at the height of 6 feet above the last coffin, under a severe penalty. It is only by some regulation of this kind, that burying several coffins in deep graves can be conducted without injuring the health of grave-diggers; and without the gas, which escapes from the earth brought up, endangering the health of those who may be occasional spectators.

In the years 1782 and 1783, when the disinterment of the burying-grounds of Les Innocents in Paris, took place under the direction of some eminent French chemists, these philosophers endeavoured to analyze this gas, but were unable to procure it. Fourcroy, speaking in their name, says:—"In vain we endeavoured to induce the grave-diggers to procure any of this elastic fluid. They uniformly refused, declaring that it was only by an unlucky accident they interfered with dead bodies in that dangerous state. The horrible odour, and the poisonous activity of this fluid announce to us that if it is mingled, as there is no reason to doubt, with hydrogenous and azotic gas holding sulphur and phosphorus in solution, ordinary and known products of putrefaction, it may contain also another deleterious vapour, whose nature has hitherto escaped philosophical research, while its terrible action upon life is too strikingly evinced. These Paris grave-diggers know," Fourcroy adds, "that the greatest danger to them arises from the disengagement of this vapour from the abdomen of carcasses in a state of incipient putrefaction." (See *Annales de Chimie*, vol. v. p. 154, as quoted in Walker's *Grave-Yards*, p. 86; and Ure's *Dictionary of Chemistry*, art. Adipocere.)

While this inflation from gas is going forward, the aqueous part of decomposition, a "fetid sanies," exudes from the body, and sometimes, when interment is delayed too long, to such an extent as to drop from the coffin before it is taken out of the house. This exudation, as already observed, is greatly accelerated and increased by putting quicklime into the coffin. In the free soil this feted sanies is diffused by the rain into the subsoil, and carried along in the water of the subsoil to its natural outlet, or to the wells which may be dug into it; and thus, while the gas of decomposition poisons both the earth and the air, the fluid matter contaminates the water.*

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* Speaking of the infectious agency in the houses in the neighborhood of that part of London called Fleet Ditch, Dr. Lynch observes:—"The great primary cause is, that the privies are in general under the staircase of the wretched hovels of the poor, and the sulphuretted hydrogen, and the carbonated hydrogen, and the noxious gases there generated, are the same gases as are generated from the dead bodies in a state of decomposition; for the evacuations from the body are decomposed animal and vegetable matter, and a dead body is the same, it is decomposition of the dead body, or a general state of disorganisation, and that produces exactly the same kind of gases. There have been instances mentioned, where people have fallen down dead from a rush of those gases in a concentrated form." (*Report on Health of Towns*, &c., p. 161.)

If the public were fully aware of the dangerous nature of the gases which proceed from the decomposition of dead bodies in crowded churchyards, and in vaults and catacombs, and of the poisonous nature of the water of decomposition:

1. They would not live in houses bordering on churchyards, which, though already full, are still used as burial-grounds.

2. They would not drink the water of wells dug in the vicinity of burial-grounds, whether

With regard to the *destruction of human bones*, we assume that to be impracticable, otherwise than by means which are altogether out of the question. The most favorable soil for their decomposition is a coarse gravel, subject to be alternately moist and dry; but, though such a soil, so circumstanced in regard to water, might be found naturally, or might be composed by art, yet these cases may be considered as equally impracticable. Instead, therefore, of endeavouring to destroy the human skeleton, let us limit our endeavours to preventing it from being desecrated by disinterment and exposure. This may be effected in various ways; but by far the most simple, effectual, and economical, as it appears to us, would be to place over the coffin, after it was deposited in the grave, a stone or slate of the same dimensions as the coffin, or even as many flat 12-inch tiles, say six, as would extend from head to foot. As the coffin and the muscular part of its contents decayed and sunk down, the stone, slate, or tiles, would follow it and press close on the bones. In consequence of this arrangement, when the ground was at any future period opened to the depth of the stone, slate, or tile, guard, it would be known that a skeleton was beneath, and the operator would cease to go farther; or, at all events, it should be rendered illegal for him to do so. If a name and date were graven in the stone, being protected from atmospheric changes, it would remain uninjured for ages, and, like the foot-marks which geologists have found in the red sandstone, might, in some far distant age, become part of the geological history of our globe. We prefer stone or tile guards, to guards of metal, because iron would soon rust, and cease to be a guard, and lead or any equally durable metal would offer a temptation to stealing. A layer two or three inches thick of stucco, Roman cement, or a plate of asphalte or oropholithe, might be used as a substitute; but stone, slate, and tiles are decidedly preferable. The slate might even be introduced within the coffin, without rendering it heavier to carry than if a lead coffin were used. Burying in a coffin made entirely of stone or slate we do not consider so likely to prevent desecration as a stone or slate guard; because there is a temptation to dig up the lower part of the stone coffin, and use it as a drinking-trough for cattle, or a cistern for a flower-garden, which is done in various places in the vicinity of old abbeys. A stone hollowed out on the under side might be better than a flat stone; because the depending edges would be a kind of side protection to the skeleton; and might, to-

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in town or country; because, though the filtration of the soil will purify the water from matter suspended in it, it will not free it from what is held in solution.

3. They would not attend service in any church or chapel whatever, in the vaults of which there were coffins, or in the floors of which interments had taken place. They would absent themselves from all such places, even if there were no immediate danger, in order, by such means as were in their power, to contribute to the discountenance of a practice by all parties allowed to be attended with disgusting and injurious results.

4. Nor would they live in houses in which the privies were not either rendered water-closets, or placed detached from the house.

5. Nor in a house adjoining an open sewer.

6. Nor would they keep a dead body in the house more than five days, or at the most, a week.

gether with the name graven on the upper side, procure more respect from those who should fall upon it accidentally in future ages, in excavating for improvements.

The *space of ground required* for a single interment, and for the interments incident to any given population, requires next to be taken into consideration. If all interments took place in the free soil, if a grave were allowed for each coffin, and the grave were never afterwards to be opened, that is, not opened for several generations, then the space required for cemeteries would be considerable. Thus, supposing graves without head-stones or ornaments of any kind to occupy a surface of 7 ft. by 3 ft. 6 in., and the average area of those having grave-stones or monuments to be 10 ft. by 5 ft., then, making an allowance for grass paths between the graves, and for gravel roads. we may take 8 ft. by 4 ft. as the average space on which to calculate the capacity of a garden or ornamental cemetery. This will give 1361 graves to an acre; and, estimating the deaths in a town population at 3 per cent. per annum, this acre would suffice for a population of 1000 souls for 45 years; or for a population of 45,000 for one year. Taking the population of London to be 1,500,000, this would require 33 acres annually, or the whole of that part of Middlesex not covered by London and its suburbs (128,540 acres) in the course of 3895 years. The average number of deaths annually in England and Wales has been ascertained to be about 336,000, which, at 1361 interments to an acre, would require 247 acres annually; or, supposing three interments in each grave 82 acres per annum. On the supposition that ground once occupied by graves was forever afterwards to be held sacred, and not subjected to cultivation of any kind: the mode of interment which would require so large a sacrifice of surface annually may be considered as impracticable; and, for our present purpose, this is the view we shall take of it. We shall, however, hereafter show how separate graves may be procured, not only for those who cannot afford grave-stones, but even for paupers; and these graves never again opened for generations. In the meantime, the mode of burying several coffins in one grave, provided these coffins are of wood, and layers of soil not less than 6 ft. in thickness interposed, and the graves, when once filled, not opened for generations, appears the best adapted for the present state of things. Supposing that on an average three interments take place in each grave or vault before it is finally closed, this will give upwards of 4000 interments to the acre; and, as the eight public cemeteries recently formed in the neighborhood of the metropolis, and the unoccupied part of the new burial-grounds recently formed by different sections of the Dissenters, contain upwards of 300 acres inclusive of the space occupied by roads and buildings, this will probably supply the demand for two centuries to come, even allowing the population to increase.

The *security of the grave* was, till within these few years, an important part of the considerations requisite to be had in view in constructing cemeteries. In some cases it was effected by surrounding the enclosure by high walls, or other effective fences; sometimes by constructing central watch-towers for stationary watchmen within; sometimes by employing perambulating watchmen; at others by burying in a grave 15 or 20 feet deep; by burying in a walled grave, covered with an iron grating built into the walls all round, some feet beneath the surface soil, and keeping the surface loose, and planted with flowers or shrubs (which, as the grave could not be disturbed without first taking these up, would by their withered state, when replanted, have told what had been attempted); and sometimes by the very extraordinary mode of letting down over the coffin a ponderous cast-iron box, to remain over it for six or eight weeks, till the body was considered to be so far decomposed as to be unfit for the purposes of the anatomist. The iron box, or case, which had remained whelmed over the coffin, but without touching it, was then disinterred and drawn up by machinery, and the wooden coffin was covered with soil, and the grave completed a second time in the usual manner. Even the poorest families, in some parts of Scotland, went to this extraordinary expense. Fortunately a law has been passed which render these precautions unnecessary, and we shall therefore take no further notice of them.

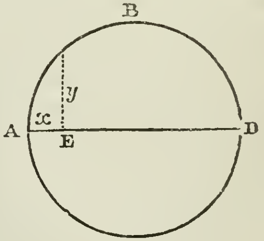
(To be continued.)

## **Mechanics and Chemistry.**

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

### *On the Strength of Cylindrical Steam Boilers.*

The circle A B D represents the section of a cylindrical boiler, and it is required to determine its resistance to the pressure of the steam.



Although the pressure is necessarily equal in every point of the periphery, and its direction every where normal to the surface of the cylinder, in consequence of inequalities in the strength of the material, the boiler is most likely to give way at some one point, D for instance, and to open by turning around some other point as a centre of motion. Let A be this turning point, and let us put

F for the force of steam on a unit of the periphery;
$x$ and $y$ for the co-ordinates of the point $m$, and
$\delta$ for the diameter of the cylinder.

Then F$\frac{dx}{ds}$ will represent the force of the steam perpendicular to the line A D on a unit of the periphery of the boiler at the point $m$, and F$\frac{dx}{ds}ds$ the same force for the space $ds$. The leverage with which this force acts to turn the section around the point A, is $x$, and, consequently, the *moment* of this differential force with reference to the point A is

$$\mathrm{F}\, x \frac{dx}{ds}\, ds.$$

The horizontal component, or that component of the force at $m$ which is parallel with the line A D, for the space $ds$ will be $\mathrm{F}\frac{dy}{ds}\, ds$, and its moment, with reference to the same point A,

$$\mathrm{F}\, y \frac{dy}{ds}\, ds.$$

The integral of the sum of these differential quantities, taken between the limits $x=o$ and $x=\delta$ will give the whole moment with reference to A; which integral is expressed by

$$\int \mathrm{F}\, x \frac{dx}{ds} ds + \int \mathrm{F}\, y \frac{dy}{ds} ds = \frac{\mathrm{F}\,\delta^2}{2},$$

observing in the operation, that $2\, y\, dy = d.\, (\delta x - x^2)$.

Now, "if P be the cohesive force of the metal of the boiler, and $t$ the thickness of the shell in inches," P$t$ will represent the resistance which the boiler will offer at D, and $\mathrm{P}t.\delta$ the *moment* of this resistance with reference to the point A; which moment, in the condition of equilibrium, must be equal to the tension, or

$$\frac{\mathrm{F}\,\delta^2}{2} = \mathrm{P}t\,\delta;$$

and, consequently, we have for the extreme force per inch which the boiler will bear,

$$\mathrm{F} = \frac{2\,\mathrm{P}t}{\delta}$$

as given by Mr. Latrobe in the last number of the Journal.

We may, if we choose, suppose the material in opposite parts of the section of the boiler, as at A and D, to possess the same strength, so that the rupture will take place at both those points simultaneously,—the upper and lower parts of the cylinder being driven asunder,—and thus avoid introducing the *moment* of the force.

In this case the above integral will be simply

$$\int \mathrm{F} \frac{dx}{ds} ds + \int \mathrm{F} \frac{dy}{ds} ds = \mathrm{F}\,\delta,$$

for the expression of the whole tension of the steam of which the effect is to part the boiler at A and D. The resistance which the shell will offer at *each* of those points is P$t$—whence the equation of condition

$$\mathrm{F}\,\delta = 2\,\mathrm{P}t.$$

and, consequently, as before,

$$\mathrm{F} = \frac{2\,\mathrm{P}t}{\delta}$$

the equation given by Mr. Latrobe in the last number of the Journal.

E.

## *Iron-Founding.*

SECTION I.—The general object of iron-founding is, to mould iron in a melted state into the various forms required for the parts of machines and other constructions. Wrought iron and steel cannot be properly melted by heat. At high temperatures, they drop away and spark off, while the main body of the metal maintains its consistency, and it undergoes rapid oxidation, as is shown by the scales which are perpetually formed on the surface. These metals are, however, in this condition rendered extremely ductile, and the wrought iron especially may be fashioned with facility into any required form by the application of the hammer. On the contrary, pig iron, of which wrought iron and steel are preparations, has peculiarly the property of liquefaction by heat, and is therefore well adapted as a material for castings, in which strength and hardness are required.

The business of the iron-founder is therefore to take advantage of the common law, according to which fluids always find their level. If, for example, a quantity of water be poured into a vessel, however curiously shaped, it first finds the bottom, and then spreads on all sides as it rises, filling every corner it can reach. The body of water must then be a perfect model in form of the interior of the vessel, and this may be seen by solidifying it in its place by the application of cold, and extracting the body of ice.

To mould a quantity of melted iron into any desired form, two things are therefore necessary; first, a model or pattern of the required form; secondly, a substance of sufficient susceptibility and adhesiveness, to receive accurately, and to retain impressions, of that pattern made upon it, against the violence of the liquid iron, when run into the mould which is thereby formed.

*Of Patterns.*—As to the material of patterns, wood is almost universally employed—yellow pine and mahogany being the kinds principally used. Of these, yellow pine is by far the most in common use. It is very suitable, being very uniform in substance, little interrupted with knots, sufficiently hard, works cleanly and with ease, and, moreover, there is plenty of it. Mahogany does excellently for small patterns, but its expense limits its application to the construction of these. It can be cut very clean, and its superior density and closeness of grain render it well fitted for nice patterns, such as of bushes for journals, small pinions, the teeth of wheels below 1 in. pitch, and in every case of a similar nature, in which the fibres of the wood may be presented endwise to the surface; whereas in working fir in this manner for minute purposes, it is apt to be broken away at the edges.

Plane-tree, beach, and red-pine are seldom used. Plane-tree has a very fine and agreeable tissue, and is very suitable for sharp, well-defined patterns, and small patterns intended for constant use, as it retains its sharpness for a long time. Red pine is remarkable for its toughness and straitness of grain, but it is coarse in the fibre. It is only employed for pinning together pieces of wood of deficient dimensions. It does well for purposes of this sort. White pine was formerly much used for patterns, but it has long been almost entirely dismissed as a material for such a purpose, on account of the roughness of its cross-cut.

After an original wood pattern is made, for purposes of light flat moulding, an iron pattern is cast off it, from which afterwards all the moulds are made, as the iron one lasts longer by a great deal than the other, and will preserve its form, which, in a wooden one, is liable to alter in the course of time, especially if the pattern be slender, and the material not thoroughly dry. Tin is frequently used instead of iron, chiefly for patterns of ornamental work, as it can much more readily be cleaned up and smoothed for service. To preserve wood patterns from the effects of damp, a coat of paint ought to be given them, and this is very serviceable in moulding the patterns of wheels, for even during the time of being amongst the sand, which is always damp, the teeth, especially those of smaller pitch, are liable to swell, and have their form destroyed. And as patterns are frequently made of wood not thoroughly dry, they shrink afterwards as they become drier; and those especially which have great extent in proportion to their thickness, such as patterns for plates, will twist at right angles to the direction of the grain, in consequence of the unequal shrinking of the opposite sides. To prevent them from altering their form, bars of wood are nailed across them, which of course leave their impressions in the sand; and it is the care of the moulder to fill these up.

*Use of Patterns.*—The construction of patterns requires from their nature in many cases to be modified, so as to render the moulding of them practicable. For example, for castings in which recesses or holes passing quite through them, are wanted, it is easy to see that were the space, in many cases actually made in the pattern, to be afterwards occupied by the sand of the moulding, it would carry off the *core* of sand as it is called, altogether. The making of these holes must be provided for in another way. Distinct cores are made by other means, having exactly the dimensions of the hole required in the casting, and that they may be securely held in their positions in the moulding, their ends project into counterpart holes in the sand, and are there fixed. These holes are formed by corresponding projections made in the pattern, named *core-prints*. For example, were it required to cast a coupling for shafts, of a cylindrical form, 12 inches deep, by 8 inches diameter outside, and 4 inside diameter, as sketched (fig. 1), a pattern of the same size, (fig. 2) is made, and two prints, *a*, *b*, are put on, in the proper positions to support the core; this is made of sand in a *box*, shown by fig. 3, which is simply two thick pieces of wood, *a*, *b*, held together by wooden pins. Into each of these, half the core hole is cut, so that when the core is formed in it, it may easily be got out by separating the

Fig. 1

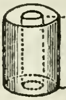


Fig. 2

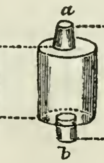


Fig. 3

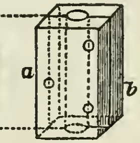
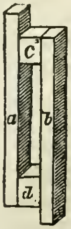


Fig. 4



halves. If then after the pattern (2) has been moulded, the core formed in the box (3) be inserted in the recesses left for it by the prints, the casting (1) will be formed, which otherwise would have been solid; for, were a pattern made like fig. 1. with the hole made through it, on withdrawing it from the sand, it would, most likely, carry off the *core* with it. In this instance, indeed, with much care on the part of the moulder, he might have managed to leave the core in its position unbroken, on account of its considerable diameter; but if it had been much smaller, say 2 inches, it could not have stood the tug of the pattern, and much less the shock of the melted iron. But, further, it is quite impracticable when the core lies horizontally, as the pattern in being withdrawn would, of course, unavoidably lift it away.

Thus, by means of distinct cores formed by boxes, holes and recesses of every kind are made in castings, if they be not already formed in the pattern.

Square cores are formed by two slips of wood, *a*, *b*, fig. 4, of the required thickness, and kept apart at the ends, by two pieces *c*, *d*, forming, by filling the space within with sand, the core required. It is, however, foreign, to our present purpose to describe the construction of patterns, further than is necessary to the elucidation of the subject under consideration.

*Materials used in Moulding.*—The principal materials used in the various branches of moulding, are sand of various kinds, clay, blackening, coal-dust, and cow-hair.

Sand is superior to all other substances as a material for forming moulds generally. For, in the first place, the hot iron has no chemical action upon it, though certainly it acts upon the matters which it is found necessary to associate with it, namely, blackening and coal. But secondly, it operates well as a conducting medium for the air expelled from the space filled by the iron, and for the other gases generated by the action of the heat on the blackening and the coal. And thirdly, it possesses considerable adhesiveness when rammed together —sufficient indeed, to make it retain its form against the pressure of the melted iron; and, moreover, it is easily made to conform itself very accurately to the surface of the pattern imbedded in it.

The sand of the London basin is the finest in the country. It is universally employed in the manufacture of fine goods, as grates, fenders, and the like. The sand in the neighborhood of Falkirk is coarser and opener in the pores, which unfits it for such work. It is employed for casting hollow ware—pots and kettles, for example, as the inclosed air escapes freely through the inside body of sand in the moulding of such articles. It affords a beautiful, smooth skin to the castings from Scotch iron, so remarkable in the hollow goods of the Carron Iron Works, in Stirlingshire, and of the Phœnix Iron Works, at Glasgow. The Belfast sand is finer than that from Falkirk, and is used principally for fine machinery castings. It is also sometimes used for facing the moulds of ornamental work, to give a fine surface. It is besides excellent for hollow moulding, when mixed with the Falkirk sand: but it is too expensive for general adoption in that way. It is a mixture of a very fine adhesive sand, and an opener kind. Rock-sand, the debris of abraded rock, and free-sand from the sea-shore are employed for making cores. The former, by itself, does very well for short cores, which open into the sand of the mouldings at both ends, as it contains a proportion of clay in its composition, which gives it cohesion. But it requires to be moderated with free-sand, to make it opener for the better escape of the air in its pores, when used for cores of considerable length, which, of course, are surrounded on all sides by the iron, except at the small portions at the extremities, by which alone the air can find exit. Free sand is also used alone for such cores, but as it wants adhesiveness, it requires to be tempered with clay water, barm, or the refuse of pease meal. In the use of the last, accuracy is required in proportioning it. The first is used in ordinary cases, and the barm only in very particular cases.

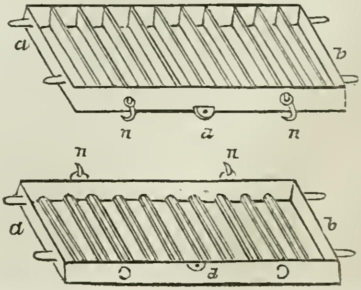
Clay is also very much employed, when mixed with sand, for loam-moulding. These ingredients are ground together with water, to give them consistency, and their proportions generally are one part of clay to eight or nine parts of sand. This, with a handful of hair mixed with it, forms ordinary *loam;* and a shovelful of horse-dung, seeds, or saw-dust, is added for *core-loam.* The purposes of these minor elements will be afterwards referred to.

Blackening and coal-dust are employed to resist the penetrating action of the iron on the sand. Blackening is simply charred oak wood ground to powder. Oak charcoal is superior to all the other ordinary wood charcoals for the purpose, as it is the heaviest. Other wood charcoals are apt to be disengaged from the surface of the mould to which they are applied, and to float in the iron while liquid, which of course defeats the object of their use. According to Mr. Mushet's experiments, oak produces 22.6 per cent., that is, fully one-fifth of its weight of charcoal. Were the iron allowed to come into direct contact with the sand of the mould, it would enter its minute interstices, and thus yield but a rough surface. To avoid this, blackening is dusted over the surface of the mould, pressed down on it, and smoothed, in cases of green sand castings, but it is mixed with clay-water, for covering loam-mouldings. Its essential property as a protector of the sand, is its inflammability. All combustible solid substances peculiarly resist liquid iron, as may be exemplified in pouring it over a smooth surface of wood. It rolls about as lively as mercury, on account of the continued effusion of gaseous matter by the combustion of the wood heaving up the iron from the surface. Now, in cases of heavy castings in green sand, as the action of the metal becomes too powerful for the blackening, this is assisted by coal-dust, which is mixed uniformly in the sand. It is never more than one-tenth of the sand in bulk, and the best kind of coal for the purpose, is the rich, hard, splint coal.

*Kinds of Moulding.*—The art of moulding may be divided into two great divisions; namely, green and dry-sand moulding, and loam-moulding. In the first division, patterns of the articles wanted are universally employed in forming the mould; in the second division, the ordinary patterns are dispensed with, the objects of this division being heavy castings of a regular form; as cylindrical bodies generally, and other circular ware, such as sugar-pans and gas-retorts. Large square vessels, water-tanks, for example, may also be made by a process of loam-moulding. The first division again embraces every other variety of article, for which there must be patterns. Dry-sand moulding is generally employed for the making of pipes, columns, shafts, and other long bodies of a cylindrical form. It is firmer and better adapted to purposes of this kind than green sand. The material of dry sand, is the loam already used in loam-moulding, called *pit-sand,* mixed in the mill with an addition of rock-sand. It is named dry-sand, in contradistinction to green-sand, because, after being moulded, it must be dried by heat to fit it for the purpose; whereas the latter is employed as it comes from its native bed, new and damp; the dampness indeed is assisted afterwards when necessary, as a certain degree of it is always requisite.

The operations of green-sand moulding are generally recognised under two great classes—hollow moulding, and flat moulding. The former includes pots, frying-pans, and every other kind of cooking ware, of a light dished form. The latter class is very extensive, and is so termed in opposition to hollow-moulding. It includes all objects of a flat nature, the various parts of grate furniture, for example, and other ornamental work generally, stoves, roans, smoothing-irons, all kinds of machinery that do not fall under loam and dry-sand moulding, for instance, all the cast-iron work of spinning and loom machinery. In fact, a kind of subdivision exists, known as job-moulding—a homely term, including machinery generally, and the heavier kind of work, distinguishing them from the ornamental and the other lighter work. A steam-engine affords in the parts of it, examples of the three kinds of moulding. The steam-cylinder and the air-pump which are round, and the condenser, which is often square, are instances of loam-castings,—the fly-wheel shaft, and the single columns supporting the framing are examples of dry-sand castings, and the beam, sole-plate, entablature, and connecting rod, if of cast-iron, are referable to the heavier green-sand casting. The cistern plates, too, are decided instances of flat-moulding.

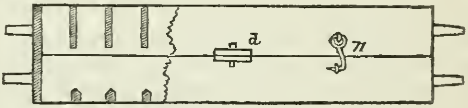
*Processes and Tools.*—The processes of green-sand moulding, and the tools employed in it, claim our first attention. In processes of green and dry-sand moulding, boxes are always employed, the purpose of which is, to contain the sand in which the pattern is moulded. These boxes are for convenience of various sizes. If there be a great or constant demand for castings of one form, boxes are made expressly for them, corresponding in form. By this plan, a saving of labour is effected, as the ramming up of useless corners with sand is avoided. For general purposes, boxes are made rectangular, and in two halves, as shown in the sketch annexed. These boxes have neither top



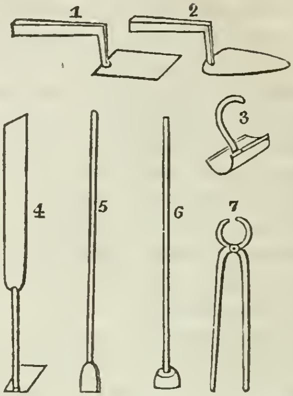
nor bottom, but each half-box, or more correctly each box, is composed of an outside rectangular frame *a*, *b*, which is generally 3, 4 or 5 inches deep for the lighter flat-moulding. They have transverse ribs joining the opposite sides at equal distances of 4½ inches between them. The object of their being open on the upper and under sides is, to allow the application of the tools for ramming the sand in the box; the ribs being at the same time sufficient as holding surfaces for the sand, which is formed into a close adhesive mass by the ramming, and, in a manner, dovetailed into the ribs. The rougher, therefore, these boxes can be made, the better—they hold the sand more effectually, and, accordingly, in casting the boxes themselves, the patterns for them are simply laid in the sand on the ground, and after being rammed, are drawn out. There is no blackening used for the surfaces of the moulding, and thus the iron enters the pores of the sand, and roughens.

As there is no covering for the mould, it being exposed to the air, this mode of casting is named open-sand casting. The exposed surface is made, however, very irregular and rough, so that this mode of casting is used only for moulding boxes, when the roughness is a virtue, and for articles of a coarse nature.

The figure annexed is a longitudinal view and partial section of a pair of boxes, in which it is seen that the ribs of the upper box are not so deep as the outside frame. They are generally an inch less deep to allow a depth of sand over the pattern that is imbedded in the sand of the lower box. The frame of this box, called the drag-box, is the same as that of the upper, but the ribs are much shorter and thicker, as it is not required to be moved about and inverted like the upper one; besides, it allows much more available depth of space for the moulding of the pattern. As the lifting and shifting of these boxes, when small, is usually managed by two men, they have two snugs or handles at each end, seen in the first figure, by which they are held. They have also usually three hooks and eyes, *n*, *n*, and three pins and holes to receive them, arranged alternately along the sides, there being two on either side, and one over the other. The pins are fixed on ears, *d*, *d*, *d*, cast on the sides of the drag box, and pass through holes made in ears on the upper box, which correspond, so that the boxes in being placed and replaced together, must have always the same relative position. The hooks and eyes hold them tightly together for casting.



The sketches annexed represent the different kinds of tools employed by flat-moulders in the execution of thin work. No. 1, is the trowel—the instrument in most frequent use by moulders. There are various sizes of it used, from ¼th to 2 inches broad in the blade, and 3 inches long generally. The purpose of the trowel is to clean away and smooth down the surface of the sand, to press down and polish the blackening, repair injured parts of the moulding, and so on. No. 2, is another form of trowel of a heart-shape. It is particularly employed for entering acute angles in a moulding, into which the square trowel evidently cannot go. No. 3, is another form of tools for managing hollow impressions in the sand. No. 4, is the form of the sleeker and cleaner. As the trowel is applicable only to open plain surfaces, this tool is used for cleaning and smoothing sunk surfaces in the sand which the ordinary trowel cannot reach—as the impression of a flange, or of any flat part of a pattern presented edgewise to the sand. The upper end is applied to the sides of such an impression for sleeking or smoothing it, and the under end goes to the bottom, where it is used both for taking up loose sand lying there, and for pressing and smoothing down the surface. It is to be noticed too, that the upper end is presented edgewise to the direction of the *spade* at the under end, so that when this is employed at the bottom of a deep recess, the upper end stands sideways to the side of the recess and permits free motion. No. 5, is the first rammer; it is about 4 feet 6 inches long, and its under face is about 2 inches + 1 inch. Sometimes the upper end, by being tapered off, is made to serve for forcing holes in the sand. No. 6, is the second rammer for finishing the work of the first. It is round in the face, about 3½ inches diameter, with a wooden shank of convenient length. No. 7, represents the pincers used for laying hold of and shifting about the castings. They have no peculiarity except in having their holding faces round and flat.



Besides these tools, shovels are used for working the sand, sieves and riddles for refining it, and bellows for blowing off loose sand from mouldings; pots for holding the parting sand and the water used in moulding, swabs for applying this water to the mouldings, being simply tufts of tow brought to a point, and separate linen bags of pease-meal and blackening, through the texture of which these materials are shaken on the sand. There are also piercers or "prickers," as they are named, being pieces of thick iron wire sharpened at one end to a point, for piercing the sand to let off air.

**To be Continued.**

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### "*An Experimental Inquiry as to the Co-efficient of Laboring Force in Overshot Water-wheels, whose diameter is equal to, or exceeds, the total descent due to the fall; and of Water-wheels moving in circular Channels.*" By Robt. Mallett, M. Inst. C. E.

This paper is partly mathematical, and partly experimental. The investigation which it details, the results of which are given in ten tables of experiments, had in view, principally, to obtain the definite solution of the following questions.

1st. With a given height of fall and head of water, or, in other words, a given descent and depth of water in the pentrough, will any diameter of wheel greater than that of the fall give an increase of laboring force (*i. e.* a better effect than the latter), or will a loss of laboring force result by so increasing the diameter?

2nd. When the head of water is necessarily variable, under what conditions will an advantage be obtained by the use of the larger wheel, and what will be the maximum advantage?

3rd. Is any increase of laboring force obtained, by causing the loaded arc of an overshot wheel to revolve in a closely fitting circular race, or conduit? and if so, what is the amount of advantage, and what the conditions for maximum effect?

The author briefly touches upon the accepted theory of water wheels, the experimental researches of Smeaton, and the recent improvements in theory, due to the analytic investigations of German and French engineers.

Smeaton, in his paper on water wheels, read to the Royal Society in May, 1759, and Dr. Robison, in his treatise on water wheels, lay down as a fixed principle, that no advantage can be obtained by making the diameter of an overshot wheel greater than that of the total descent, minus so much as is requisite to give the water, on reaching the wheel, its proper velocity.

The author, however, contends that while the reasoning of the latter is inconclusive, there are some circumstances which are necessarily in favor of the larger wheel, and that conditions may occur in practice, in which it is desirable to use the larger wheel, even at some sacrifice of power; and that hence it is important to ascertain its co-efficient of laboring force, as compared with that of the size assigned by Smeaton for maximum effect.

The author states, first, the general proposition, "that the laboring force ("travail" of French writers,) or "mechanical power" of Smeaton, of any machine for transferring the motive power of water "is equal to that of the whole moving power employed—minus the half of the *vis viva* lost by the water on entering the machine, and minus the half of the *vis viva* due to the velocity of the water on quitting it." He deduces from the theory, the following results, coinciding with the conclusions obtained by experiment.

1st. If the portion of the total descent passed through by the water before it reaches the wheel be given, the velocity of the circumference should be one-half that due to this height.

2nd. If the velocity of the circumference be given, the water must descend through such a fraction of the whole fall before reaching the wheel, as will generate the above velocity.

3rd. The maximum of laboring force is greater, as the velocity of the wheel is less; and its limit, theoretically, approaches that due to the whole fall.

General equations are given, expressing the amount of laboring force in all the conditions considered, and their maxima.

One of the principal advantages of using an overshot wheel greater in diameter than the height of the fall, is the power thus afforded, of rendering available any additional head of water occurring at intervals, from freshes or other causes, by admitting the water upon the wheel at higher levels.

The first course of experiments is dedicated to the determination of the comparative value of two water wheels, one of whose diameter is equal to the whole fall, and the other to the head and fall, or to the total descent; by the head, being in every case understood, the efficient head, or that due to the real velocity of efflux at the shuttle, as determined according to Smeaton's mode of experimenting.

The apparatus employed in this research consisted of two accurately made models of overshot wheels, with curved buckets. These were made of tin plate, the arms being of brass, and the axles of cast iron. Special contrivances were adopted to measure the weight of water which passed through either wheel during each experiment, to preserve the head of water strictly constant, and to determine the number of revolutions, and the speed of the wheels.

One wheel was 25.5 inches diameter, the other, 33 inches diameter. The value of the laboring force was determined directly, by the elevation of known weights to a height, by a silken cord over a pulley; the altitude being read off on a fixed rule placed vertically against a lofty chimney; and in other experiments, relatively by the speed of rotation given to a regulating fly or vane. The depth of the efficient head was 6 inches in all cases.

The weight of water passed through either wheel in one experiment, was always 1000 pounds avoirdupoise.

All the principal results given in the table accompanying the paper, are the average of five good experiments; from the large scale upon which these were conducted, the accurate construction of the apparatus, and the care bestowed upon the research, which was undertaken with reference to an actual case in the author's professional practice, he is disposed to give much confidence to the results.

The weight of water contained in the loaded arc of each wheel is accurately ascertained, and in the tables which accompany the paper, the results of the several experiments are given at length.

The velocity of the wheels, under different circumstances, is carefully noted and discussed with respect to the maximum force.

The author next ascertains the value of the circular conduits, and states that generally, in round numbers, there is an economy of laboring force, amounting to from 8 to 11 per cent. of the power of the fall, obtained by the use of a conduit to retain the water in the lower part of the buckets of an overshot wheel, whose diameter is equal to the fall. The velocity of a water wheel working thus, may vary through a larger range without a material loss of power, and a steady motion is continued to a lower velocity than when it is working in a free race.

The author finally arrives at the following general practical conclusions:—

1st. When the depth of water in the reservoir is invariable, the diameter of the water-wheel should never be greater than the entire height of the fall, less, so much of it as may be requisite to give the water a proper velocity on entering the buckets.

2nd. When the depth of water in the reservoir varies considerably and unavoidably, an advantage may be obtained by applying a larger wheel, dependent upon the extent of fluctuation and ratio in time, that the water is at its highest and lowest levels during a given prolonged period; if this be a ratio of equality in time, there will be no advantage; and hence, in practice, the cases will be rare when any advantage will obtain by the use of an overshot wheel, greater in diameter than the height of fall—minus, the head due to the required velocity of the water reaching the wheel.

3rd. If the level of the water in the reservoir never fall below the mean depth of the reservoir, when at the highest and lowest, and the average depth be between an eighth and a tenth of the height of the fall, then the average laboring force of the large wheel will be greater than that of the small one; and it will, of course, retain its increased advantage at periods of increased depth of the reservoir.

Dr. Robison's views, therefore, upon this branch of the subject, should, he contends, receive a limitation.

A positive advantage is obtained by the use of the conduit varying with the conditions of the wheel and fall, of nearly 11 per cent. of the total power.

The value increases with the wheel's velocity up to 4½ feet per second, or to 6 feet per second, in large wheels. Hence, he argues, that it is practicable to increase the efficiency of the best overshot wheels, as now usually made, at least 10 per cent. by this application. The only objections urged against the use of the conduit are of a practical character, relating to the difficulty of making it fit close, of repair, &c.; but however these may have applied to the rude workmanship of the older wooden wheels, with wood or stone conduits, they are unimportant, as referring to modern water-wheels made of iron. The conduits may be also made of cast-iron, provided with adjusting screws, and hence of being always kept fitting, readily repaired, and capable of being withdrawn from the circumference of the wheel in time of frost, &c.

The paper is illustrated by a drawing, showing the elevation and partial sections of the experimental apparatus, and a diagram showing the full size of the loaded arc of each model.

Mr. Farey observed, that the result arrived at by the experiments, appeared to correspond nearly with those recorded by Smeaton, who had experimented upon, and used practically, both kinds of wheels. The buckets of the model wheels used in the experiments did not appear to be of the best form, and they were entirely filled with water; hence an apparent advantage had been obtained, by the use of the circular conduit to retain the water in the buckets. But that would not be realized in practice, for as the form of the bucket regulated the point at which the water quitted it, and it was the practice of the modern millwrights to make the wheels very broad, in order that the buckets should not be filled to more than one-third of their depth, the circular conduits became less useful, and in fact were now seldom used. Smeaton's practice was, to entirely fill the buckets with water, but he never adhered to the slow velocity of revolution which he recommended theoretically in his paper to the Royal Society.

Mr. Fairbairn had adopted broad wheels with an improved form of bucket, partially filled, and had obtained a more regular motion, particularly at high velocities.

Mr. Farey promised to present to the Institution, a copy of the method of calculation adopted by Smeaton for water-wheels.

Mr. Taylor corroborated Mr. Farey's statement of the advantage of using broad wheels, with the buckets of a fine pitch and partially filled; circular conduits then became unnecessary: this was practiced among the millwrights in North Wales with eminent success, and a velocity of six feet per second was given to the wheel.

Mr. Homersham believed that in Smeaton's latter works he increased the velocity of his wheels to six feet per second.

Mr. Rennie gave great credit to the author for the ingenuity of the apparatus with which the experiments were tried, and for the clearness of the tabulated results; but owing to the necessary limited size of the model wheels, he feared the results could not be relied upon for application in practice to large wheels. The experiments of Borda, Bossut, Smeaton, Banks and others, were all liable to the same objection.

The best modern experiments are those by the Franklin Institute, by Poncelet, and by Morin.

The result of these might be thus:

| | | | | | |
|---|---|---|---|---|---|
| Undershot wheel, | the ratio | of power | to effect | varied from | 0.27 to 0.30 |
| Breast wheels, | " | " | " | " | 0.45 to 0.50 |
| Overshot wheels, | " | " | " | " | 0.60 to 0.80 |
| Average, | " | " | " | " | 0.60 |

The velocity of the old English water-wheels was generally about three feet per second; the American wheels four feet, and the French wheels six feet: this latter speed was now adopted by the best millwrights in England. Mr. Hughes, at Mr. Gott's factory at Leeds, and Mr. Fairbairn, had found advantage from it; the latter also had a particular contrivance for carrying off the air freely from the buckets.

It was important to regulate the thickness of the sheet of water running over the shuttle upon the wheel; four to five inches was found in practice to be the maximum depth allowed.

The object being to utilize the greatest height of fall and the greatest available quantity of water, by means of properly constructed openings and such sluice-gates as were first introduced by the late Mr. Rennie for the breast-wheels constructed by him, instead of penning up the water in a trough, it was made to flow in a sheet of regular thickness over the top of the shuttle, and by a self-regulating apparatus to adjust itself at all times to the height of the water; thus obtaining the advantage of the full height of the fall at its surface, and obviating the necessity for the apparatus proposed by Mr. Mallett.

Mr. Mallett begged to dissent from the validity of the objections which had been made to the practical value of his experiments. With respect to the form of the bucket, that used by him could not, he contended, be called a bad form, although it might be susceptible of improvement; but as the experiments were altogether comparative, it was foreign to the question whether the form was bad or good, the same having been used in both wheels.

As it was shown that a certain relation subsisted between two water-wheels with the same total descent, but with different diameters, as to their co-efficient of laboring force, a proportional relation would exist with any worse or better form of bucket. The results considered as absolute measures of effect, being obtained with a form of bucket which approached nearer to the best forms now in use, than did those of Smeaton, or any other experimenter, were more applicable to modern practice, and therefore he must consider his results, as not without utility.

With regard to the custom of only partially filling the buckets, it must be remarked that buckets of the best forms begin to spill their contents before arriving at the lowest point of the loaded arc; the partial filling could, therefore, only palliate the evil which the circular conduit was designed to remedy. He must, however, contend that a positive disadvantage attended the partial filling. A permanent loss of fall was produced equal to the distance between the centres of gravity of the fall, and of the empty portions of the top bucket at the moment it had passed the sluice; this distance could be but little varied by the fineness of pitch of the bucket, and depended more on the depth of the shrouding. That there was a constant loss of laboring force by a practical diminution of the effective leverage, or a reduction in the "moment" of the loaded arc. That as the wheel revolved, the centre of gravity of the fluid contained in each bucket, as it approached the lower portion of the loaded arc, was transferred to a greater distance from the centre of motion even before the contents commenced spilling; but the angular motion of the centre of gravity of any one bucket was at first that due to its distance from the centre of motion of the wheel, or to its radius; and as the radius increased, a greater angular velocity would be acquired by the water which had changed its position on approaching the lower point of the wheel; but this increased velocity was given at the expense of the power of the wheel, and hence a partially filled bucket would, he contended, be always attended with a loss of laboring force. To the last objection, a full bucket was not liable.

From all these reasons, he felt justified in concluding, that the use of the circular conduit was more advantageous than the practice of partially filling the buckets.

With respect to the shuttle delivering the water over the top, where the head of water and the fall were constant, no advantage could be obtained by the use of a wheel greater in diameter than the total descent; it was assumed that this form of shuttle would be used in order always to deliver the water as high as possible upon the periphery of the wheel; but the question was, "If the head be variable, what should be the diameter of the wheel to secure the best effect?" The paper showed that a wheel whose diameter was equal to the total descent, when the head was a maximum, did not always give the greatest average laboring force. The question was therefore independent of the sort of shuttle used; it assumed the power of always admitting the water upon the wheel at the highest point of the total descent, and sought to establish the best relation between the diameter of the wheel and the whole descent when the head alone was variable, according to given conditions. The results of this part of the investigation, therefore, while they admitted the full value of Mr. Rennie's shuttle, went further, and pointed out the limits of its useful application.

He was fully aware of the prejudice which existed against the circular conduit, and once participated in it; but his attention had been forcibly drawn to it in his practice, and having used them very beneficially upon wheels of 40, 50, and 60 horses' power, which he had constructed for mining purposes, he wished to draw the attention of the profession to the consideration of their practical merits when adapted to good wheels. Civ. Eng. & Arch. Journ.

## *Experiments and Observations on Möser's Discovery, proving the Effect is neither due to Light nor Heat.* By HORATIO PRATER.

It is proposed now to demonstrate, that the radiation discovered by Möser is not invisible light, as he supposes, nor heat, as has since been supposed. For, first, where is the evidence that bodies absorb light? Some few, certainly, have been shown so to do; but surely not the metals, &c. &c., which exhibit the greatest facility in receiving and giving the impressions discovered by Möser. It seems, *à priori*, more probable that the radiation in question should consist of heat (which we know exists in all matters) than of light. Accordingly, Mr. Hunt has written an elaborate paper in favor of the supposition that such radiation consists of heat. In the course of this essay, however, it will appear, that neither of these suppositions is correct.

1. *With regard to the nature of the substances that produce spectra.*—Every substance I have tried has produced its spectrum when left on a polished copper plate. Coins, whether of gold, silver, or copper, platinum, nickel, brass, pieces of glass, wafers (red, blue, or white), peppermint or rose drops, whalebone, talc, gum, a horsehair ring, lava from Vesuvius, Indian rubber (but slight), and sealing wax. This last, left ten days, gave a whitish grey *permanent*[*] spectrum, clearer than any of the others, though the wax and plate were both kept dry as usual. The impression on a small brass seal

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[*] By a *permanent* spectrum is always meant, in this essay, a spectrum that remains when the substances or coins are removed—not a spectrum which cannot be rubbed off by *gentle* friction, for all the above *permanent* spectra are yet soon effaced by friction.

(a P) was very obvious when the plate was breathed on. The seal had been left ten days.[*]

2. *Effects of Dissimilar Metals.*—It has been asserted, that when a gold or silver coin is placed on a copper plate, the effect is greater than when a copper coin, &c. is placed on the same metal. When heat is used, this position is true, as will be shown hereafter; but when the plates and coins are both kept cold, (exposed to external air, for instance, in March,) a farthing, on two different occasions, in an hour, left as good a spectral image as a sovereign,—I thought, a better one.

It was, however, remarkable, when a heat of 160° was applied to this plate, that the spectrum of the copper soon became invisible, while that of the gold was apparently not at all diminished. This experiment was repeated twice with the same result. I likewise found that, though the spectrum of the copper was to appearance, *at first*, as good as that of gold or silver, yet that it began to disappear much sooner, after a few breathings on the plate, than did the spectrum produced by gold or silver. *On the whole*, therefore, it seems right to admit that the effect is greater when dissimilar metals are used.

3. *Effect of Unequal Heat on the Plate and Coins.*—It has also been asserted, that when the copper coin is heated, and the metal plate of copper kept very cool, that the effect is increased. I have, however, not been able to satisfy myself of the truth of this statement. A penny and a farthing, heated to between 130° and 160°, and laid on a cold copper plate half an hour, did not appear to leave even so good a spectrum as two of the same coins left to cool for half an hour outside the window, by the side of the plate itself, before being placed on the plate. All the coins were placed on the plate at the same time, and left the same time. Neither could I perceive any difference when one sovereign was heated and the other not, both being placed on the same copper plate.

4. *Effect of Heat Generally.*—In order to ascertain whether heat hastens the impression, the following experiments were made:—1. A bright half-sovereign, a bright half-penny, and a dull one, were heated to about 150° on polished copper plate. The half sovereign left a *permanent* impression; and both the halfpence left spectra visible only by breathing. It was obvious from this experiment and others, that heat increases the effect where *contact is permitted*,[†] since

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[*] It left a permanent spectrum of its *margin*. Coins left a similar time do the same; *the part where they have remained retaining its polish.* The permanent spectrum then, in such cases, plainly depends on the substances preserving the plate from oxidation by contact or proximity. I add proximity, because a half-crown or penny resting on a fourpenny piece, placed on the plate, likewise leaves its *permanent* spectrum. The free circulation of the air is impeded here in consequence of the extreme proximity, just as it is by actual contact. Hence the oxidation being less in all such cases than in the parts external to the coins, we have of necessity the permanent spectra.

[†] Although the mark is permanent in such cases, still it very easily rubs off, even when gold has remained five hours on heated copper plates; and no spectral figure is left when the part is breathed on, after the plate has been well rubbed. As this is the case, such permanent mark is not to be considered as a *different* effect, but only as a *higher degree* of the same effect as that caused by mere imposition without heat. I found all the things mentioned in Section 1. gave a *permanent* spectrum if left eleven days, but only one rendered visible by breathing, being left but a few hours.

the impression is permanent. Accordingly it was deemed right to tr if heat has this effect when the coin is at a distance from the copper plate.

I put a silver fourpenny piece on the plate, and on the fourpenny piece I put a penny. I found that when these remained only twenty-four hours, that no spectral image of the penny was produced; bu on remaining forty-eight hours one was apparent. In this last case the lettering of the fourpenny piece became almost visible when breathed upon, but without this no mark of it was perceptible. The penny piece, however, left its mark without being breathed upon—an annular *bright* mark, which was not rendered more or less distinct by being breathed on. The spectrum of the fourpenny piece was alone brought into view by this.* The place where this had laid was exactly as bright as that covered by the penny. In fact, the copper plate seemed preserved from oxidation by the contact and proximity of these coins. Thus, then, it appeared to require forty-eight hours for a spectrum of the penny piece to be produced—the spectrum of a coin *not in contact.* The same experiment being made at a heat of 160°, no spectrum of the penny appeared after one hour, though the fourpenny piece had left a strong impression.

Ditto, continued for five hours, a spectrum of the penny was *just* visible, and only so when the plate was held in a particular position with regard to light.

A half-crown piece being laid on a half-sovereign, and the same heat continued five hours on the same plate, the half-sovereign left a still better impression than the fourpenny piece † above mentioned, and the half-crown had also made a *permanent* spectrum very visible.

A farthing, which had rested the same time *on* the plate, left no permanent spectrum, but only one slightly visible by breathing. Even when pressed upon by two pence, and left eight hours, it left only a *barely visible* permanent spectrum: so a brass medal. These spectra being rendered far more visible by breathing, could hardly be considered permanent spectra.

These experiments show :—1st. That heat much increases the rapidity of the radiation, *even when the object is not in direct contact;* and 2ndly. That it takes place much more energetically from gold and silver than from copper (a copper plate being used.) They also show that a permanent spectrum is to be considered only as a *higher degree* of that produced or rendered apparent by breathing,

A sovereign, two hours on a very thin lamina of talc, at the above heat, gave no spectrum; talc alone gave its spectrum; nor did a halfpenny, eight hours on the same at the same heat; nor a shilling (new) on a thin piece of glass, the shilling being under a halfpenny.

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*However, after six or eight days, *as this began to tarnish*, the spectrum of the fourpenny piece became visible without breathing on it. Yet nothing had been done, except that the plate had been heated to about 150° once or twice for other experiments.

†When the plate was rubbed pretty strongly with chamois leather only, the spectra of the half-sovereign and four-penny piece were soon effaced; while these of the half-crown and penny (not having been in contact with the plate) remained.

The talc and glass in these cases alone gave a spectrum; the talc a better and more permanent one than the glass.* I should have said the talc was on copper-plate.

The spectrum of the penny, in the experiment lately detailed, is equally visible when the experiment is made on glass; but polished metals seem to show it the best.

When glass is used, there is, after from twenty-four to forty-eight hours, a slight deposition of dust, &c. around the parts which are not covered by the penny, and thus a round mark (permanent spectrum) is visible on removing the penny, even before breathing at all; still on rubbing it off *till nothing is visible*, and breathing on it again, the spectrum of the penny appears, as well as of the fourpenny piece, proving that dust adheres much more strongly than we should have supposed, or perhaps better,—leaves its mark behind with greater pertinacity.

That this is the true explanation of the appearance of a spectrum, when the coin is not in direct contact with glass, was to me rendered clear by another experiment, in which a half-crown was left on one sixpence, and a penny on another, on a clean glass plate *covered over with paper, and kept in a closet* for ninety-six hours; yet on examination, neither a permanent spectrum, nor even an evanescent one by breathing, was perceptible either of the half-crown or penny; the sixpences alone had left spectra (which, however, were only visible by breathing), that under the half-crown being the clearest. Yet the penny and half-crown were in the best condition for giving spectra, for the surfaces of both were tarnished, and that of the copper purposely so.

This result induced me to try the same with a copper plate, and I found that when a bright half-crown (having been well boiled in water and then polished) was placed on a fourpenny piece, similarly treated, and left forty-eight hours *covered* in the closet as above, that the half-crown left no spectrum, even evanescent. Neither did a *purposely* tarnished penny placed on another fourpenny piece, and left the same time.

5. *As regards the Distance from the Plate at which Images may be taken.*—A silver fourpenny piece is about the one-twentieth of an inch in thickness, and at this distance we have seen silver, copper, and of course gold, give a spectrum image on a copper plate. But on putting a half-crown and two sixpences and a half-franc piece, making the distance from the plate more than one-tenth of an inch, no spectrum of the half-crown was made, although the experiment was continued for twelve successive days and nights. Neither was any made by removing the half-franc piece (thus making the distance only one-tenth of an inch), and continuing heat at 160° or so for five hours.

A sovereign fixed at three-quarters of an inch, and a small brass medal at somewhat less than half an inch, from a polished copper plate, and continued in such position for seventeen days and nights in a little closed deal box, gave not the least vestiges of spectra; neither did a fourpenny piece left at one-fifth of an inch, nor a card plate (engraved) left the one-tenth of an inch, for eleven days. The copper plate had remained *perfectly polished* in both experiments; and this is worthy of remark, as showing that in *confined* air copper does not oxidate perceptibly. Another plate left in the *same* room was completely tarnished in five or six days.

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* A sovereign on a silver four-penny piece two hours, gave only a very feeble permanent spectrum; the silver leaving, of course, a well marked spectrum.

A fourpenny piece, about the one-twentieth of an inch, under a silver plate for eleven days, gave scarcely a perceptible spectrum; though a farthing, on which the plate *had rested*, gave a good spectrum, but not a *permanent* one, *(i. e.* breathing was required to show it.)

A fourpenny piece is about the one-twentieth of an inch in thickness, and this seems the greatest distance an image can be taken by the above plan. But even at this distance I have not succeeded, if the half-crown laid on the fourpenny piece is *perfectly* polished, and *all external dust, &c,. carefully excluded* by the box just mentioned—(see Sec. 8, on the comparative polish of metals).

Lond. Athenæum.

(To be continued.)

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## *Preparation of Bicarbonate of Soda.* By M. Artus.

According to the author, the property of charcoal to condense gases may be turned to good account in the preparation of bicarbonate of soda.

2 parts of effloresced carbonate of soda are mixed with 1 part freshly heated pulverized charcoal (from soft wood), the mass moistened with some water, and then brought into a high cylinder, and carbonic acid passed into it. This gas is allowed to act for 24 hours, when the mass is taken out, pulverized, some water added to it, and again returned into the cylinder, and carbonic acid passed into it. The same operation is twice repeated, the mass is then taken out of the cylinder and treated with 8 parts of hot water, filtered while hot, and the solution left to crystalize. The bicarbonate of soda formed crystalizes from the solution, while the neutral carbonate remains dissolved in the mother-ley, which is poured off, and may be employed for other purposes. The residuous bicarbonate of soda is then washed with a little cold water, to remove the last traces of any adhering carbonate, and is then dried.

In this manner somewhat more than two-thirds of the quantity of neutral carbonate employed, is obtained of bicarbonate of excellent quality. The charcoal assists greatly in the absorption of the carbonic acid gas, hastening the operation, and at the same time the neutral carbonate of soda becomes of a beautiful white by contact with the charcoal.—*Allgem. Pharmaceutishe Zeitschrift* von Artus, No. I.

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# Civil Engineering.

## *Mr. Vignoles' Lectures on Civil Engineering, at the London University College.*

[Continued from Page 28.]

### LECTURE XI.

In resuming the subject of the Upper Works of Railways, the Professor said he would enter briefly into the consideration of the strongest form of rail, after explaining those points applicable alike to cast and wrought iron bars. First, a certain breadth was required for the bearing surface of the rail, for the wheel to run upon, and this breadth should be such as not to be likely to produce improper action or grooving, in the tire or tread of the wheel, and, at the same time, not to be increased so as to make the rail needlessly heavy; there must also be a sufficient depth or thickness of that bearing surface, to make it strong enough to withstand abrasion, and render the rail sufficiently stiff, and capable fully of sustaining the action of the driving-wheels of the locomotive engine. Hitherto the established breadth seemed to have been about two and a half inches on the top web, or button, and Mr. Vignoles thought, from experience, that that breadth should be considered the *minimum;* however, the strength of this bearing part of the rail, being as the breadth and square of the depth, a greater breadth than absolutely necessary to prevent the tire of the wheels being grooved, would add to the weight of the rail, without increasing the strength more than in the direct ratio of the breadth, whilst the same quantity of material, disposed in terms of the depth, increases the strength in the duplicate ratio. Considering the great increase of weight in the locomotive engine of late years, and the continued wear and tear on the rail, from the action of the driving-wheels, and looking to the state of the iron of the upper works of those railways which have not very heavy bearing surfaces, it would seem that, while two and a half inches is a *minimum* of breadth, the chief attention is now required to the proper depth, to resist abrasion and exfoliation which takes place, especially if the iron is not perfectly well rolled. Railway bars are compounded of fagotted iron, and if the pieces are not properly welded the bearing edge is broken down, and peels off; but, supposing the iron good, and the manufacture perfect, the heavy effects of the engine must be provided against, and experience shows that an inch and a half is not too much for the depth of the top web, or bearing part of the rail, and two and a half inches being the breadth, then three and three-quarters—or, say four square inches—should constitute the sectional area of the part that is exposed in receiving the direct action of the driving-wheels; this is the section actually requisite, and the greatest additional strength being to be obtained by increasing the depth, if possible, this is the point to be attended to. It thus appears that a weight of 36 lbs. per yard is required to sustain the engine, and all beyond will belong to the mode of attaching the rail to the support below.

In treating of the wear and tear of rails, Mr. Nicholas Wood has given some curious and interesting results of experience; but the weight of the locomotive engines used is stated to have been only 10 tons, and of this the weight on the driving-wheels would probably not exceed six or seven tons. The result of a variety of experiments on the malleable iron rails of the Stockton and Darlington Railway, gave one-tenth of a pound per yard as the absolute amount of fair abrasion; some statements, however, made it much higher, being one-sixth of a pound. On the Killingworth Colliery, it was one-eighth of a pound. On the Liverpool and Manchester Railway, some years ago, three rails were taken up, carefully cleaned and weighed, relaid, and taken up again at the end of one, and again at the end of two years: the wear was found constant, and about one-tenth of a pound per yard per annum. If we were to take this to be the true wear, and suppose it to arise wholly on the upper surface of the rail, the result would be but the 84th part of an inch in depth, and it might be supposed to take 100 years to wear away a rail from mere abrasion. But later experience shows that the increased weight of engines acts very destructively on rails whose upper webs are not sufficiently strong, and of the best manufacture. We may take 10 tons as the present average weight on the driving-wheels of a locomotive engine; and, if this is to be effectually provided for, the button, or bearing part of the rail, must not be less than 40 lbs. to the yard. Now the form of the remaining part of the rail will depend upon the manner in which it is to be fastened down to the support below, either by being fixed in a chair, which is itself to be again fastened to something else, or by being screwed down, as the rails on the Great Western, Croydon, and the new part of the Greenwich Railway; or, finally, secured in the simple manner described in the last lecture. A comparatively very small addition to the theoretical form of rail to be sustained in a chair, gives a section which has the advantage of being capable of being turned in either direction, or vertical position, and hence the top and bottom of the rails have, of late, as previously stated, been made equal and similar, connected by a neck of proportionate dimensions. With the present heavy rails, of nearly 80 lbs. to the yard, the average weight of the chairs, including the joint chairs, may be taken at 20 lbs. per yard, reducing the intervals of support to that constant distance. Thus, we have an aggregate of nearly 100 lbs. weight of iron per yard of each single rail. If, then, we could in any way get rid of the extra weight required to fasten the rail into the chair, and dispense with the chair altogether, it seemed to Mr. Vignoles to be desirable to do so, provided the object in view was equally well attained; and he contended that such would be the case with a 50 lbs. rail attached, in the mode before described, to a longitudinal bearing of timber; for the whole strength of the upper or bearing part would be retained, that being as the breadth and the square of the depth; thus, with a weight of iron just one-half, would be equally efficacious, and it only remained to compare the supports in either case. Now, as stone blocks seemed to be discarded by universal consent, the question of the supports below is narrowed to that of *transverse* or of *longitudinal* wood sleepers. Sufficient experience had been obtained to warrant the conclusion that, for the purposes of this argument, the cost of fastening and of laying the rails, ballasting, drains, &c., taken as a whole, were nearly the same for both systems, and it only remained to contrast the quantities of timber, and, always considering a locomotive line to be the one to be made, it may be stated that this cubing was about double for the longitudinal system to that in the transverse method of laying the sleepers. In short, looking at first cost only, there was a saving of 100 lbs. of iron, and an increase of two cubic feet of timber in each yard of single trackway of the former over the latter mode, so that strictly the longitudinal system was the cheapest; but to avoid minor objections, let the cost of each be taken to be the same, which was giving a decided concession in favor of the transverse system. But this was a very narrow view to take of the question, which wholly omitted the economical results from diminished wear and tear of the engines, of the railway, and of the carriages, as had been most especially exemplified on the Dublin and Kingstown Railway, where the massy granite blocks originally laid down had been all replaced by longitudinal sleepers, and though the old light 45 lb. rails and 15 lb. chairs were retained, the diminution of the annual maintenance was most remarkable, though there was not a railway in the United Kingdom were so many passengers were carried daily throughout the year.

The expense of keeping up the double way, now that the system of longitudinal timbers has been quite carried out, is less than one-third of the corresponding expense per mile per annum of maintaining the London and Birmingham Railway. Mr. Vignoles then read a variety of tabular results of the cost of the three various systems, going through all the details, and pointing out the exact measures and quantities, and stating the actual expenditure on the upper works of various lines of railway. The result seemed, that for a double line of railway—upper works, properly laid after the bed of the road was duly prepared, including all the items under that head, which were enumerated in a former lecture, and calculating, for the present heavy and powerful locomotive engine, that no less a sum than £5000, and, in most cases, £6000, per mile was necessary, and that, in many instances, it had reached nearly £7000—the market price of iron and timber, also the quality of the latter, the greater or less facility of obtaining materials for ballast, &c., affecting the amount, and these large sums were independent of the earthwork, masonry, land, fencing, management, stations, carrying establishment, &c. Mr. Vignoles also gave a number of drawings and diagrams contrasting the three systems, and exhibiting, in a very explanatory manner, the modes of laying and fastening. He also exhibited the rail, chair and fastenings, for the transverse method, with all the recent improvements introduced by Mr. Cubitt, on the South-Eastern Railway, and as manufactured by Messrs. May, of Ipswich, and then produced the rail with the dove-tailed slot, and the mode of attachment to longitudinal half baulks of timber, repeatedly alluded to in this and the preceding lecture, observing forcibly, that, if the same effective results were obtainable by the latter simple method as by the former complicated one, it was not only to be preferred in this kingdom, but was peculiarly eligible for such countries as Russia, Poland, Germany, in general, France and America, where wood is usually in great abundance, and where iron is comparatively scarce, especially in the form required for railway bars, and, of course, the prices became in proportion. Mr. Vignoles quoted largely from the works and reports of Tredgold, Barlow, and Lecount, and stated a number of mathematical and empirical rules laid down by those authors, which, he stated, were chiefly relating to rails supported at intervals, but, though he felt it right to lay them before the class, he considered that farther experiments and investigations were requisite, and particularly in reference to the perfect combination in one support of the iron and timber in the longitudinal system, as explained and advocated by him, of which the Professor insisted, the great advantage and peculiarity was that of obtaining a perfect fastening, independent of the fibre of the wood, or the tenacity of the screws or bolts therein, and of obviating the hitherto well-founded objections to the mode of attaching rails having a continuous bearing, which had not been able to prevent a vertical play of the iron on the timber.

## SECOND COURSE—LECTURE XII.—RAILWAY ESTIMATES.

This lecture had reference to the consideration of estimates, as applied to railways—that is, to ascertain lineal dimensions, superficies, and cubic contents, and affixing the proper rateable prices, to work out the monied results. The Professor said, that, probably, the most ready way to give a general idea on this subject would be to go briefly over the several heads to be considered in framing an estimate. It was assumed that proper plans and sections of the work had been prepared in a skilful manner beforehand, Mr. Vignoles strongly insisting on the necessity and importance of having all such documents furnished on a much larger scale, and with vastly more attention to accuracy and detail, than had often hitherto been the case, particularly for Parliamentary estimates, observing, that erroneous data and calculations could not but result from a neglect of this rule: and, he stated, that, although many of the standing orders of Parliament were annoying in some respects, yet the principle on which they were framed, went to compel a compliance with forms, in doing which, greater previous investigation and accuracy of plans and sections, became absolutely indispensable.

The *quantity of land* required formed naturally the first item of an estimate. It was but seldom, indeed, that the very small economy of taking land for one line of railway only was adopted. To a given breadth, therefore, for a double line—say, from eight to ten yards—must be added the necessary allowance for fencing and ditching—say, three yards on each side—making a constant breadth of fourteen to sixteen yards of land throughout, independent of the necessary slopes in excavations and embankments; the additional quantity of these, depends, of course, on the depth of the cutting, or height of the bank, in the various places, and on the ratio of the slopes of the earthwork. Suppose, in a cutting or banking of ten feet, this ratio to be one horizontal to one perpendicular, then, such slopes of one to one require ten feet additional breadth of land on each side—together, twenty feet—viz., twice the depth or height to be added as a further breadth, beyond the constant one for the railway and fencing. In like manner, for slopes of one and a half, two, two and a half, or three to one respectively, multiply the varying depths or heights of cutting or embanking by three, four, five or six, as the case may be, for the necessarily augmented breadth of land due to the slopes, along their several extents; and thus, from the lengths measured, and the heights figured, on the section, the varying quantities of land are obtained, multiplying length by breadth, and reducing the areas to acres and parts for agricultural districts, and to square yards for land in towns and their immediate vicinities. For the prices to be assigned to these superficial quantities, the engineer must depend on the land valuer, who is also to judge of the amount of contingent damages. On an average, the actual quantity of land for a double line of railway, including the slopes of earthwork, may be taken at ten acres to the mile, but the precise areas must be ascertained in detail in the way explained. The cost of land for many of the leading lines of railway had been as much as £5000 per mile for the whole of their length. The cost of land for lines at a greater distance from the metropolis was less—still, from the numerous contingent after-charges, in respect of land, the sums were large, and had often far exceeded the original estimates.

The *fencing of the land* comes within the province of the engineer, though it is sometimes comprised in the item of land. The mode of fencing must always be regulated upon the custom and materials of the country. Drystone walls, earth mounds with furze hedges, posts and rails, quickset hedges, and broad-side ditches or drains, are the principal kinds of fencing through agricultural lands; walls of brick or masonry, set in mortar, are generally called for through towns or building land. The several lengths of each of these are ascertained from the plans; the prices are obtained in the localities. Including farm-gates, the cost of fencing varies from 1*s.* 6*d.* to 3*s.* per yard lineal in the country. In the vicinity of towns, for stations, &c., the price will vary from 5*s.* up to 10*s.* per yard, according to circumstances, which it must be the business of the engineer to ascertain.

The third item is usually that of *Earthwork*—that is, to reduce the undulating natural surface of the ground to the railway level or gradient, by cutting through hills, and filling across valleys. Mr. Vignoles having, in the first course, entered at large into the consideration of earthwork, thought it unnecessary to say much here. The price of the earthwork depends abstractedly on the average work that an able-bodied man can perform in a day, in various soils—this it should be the study of the engineer to determine. The mere price to the workman, for getting and filling, may be taken at from 2*d.* to 5*d.* per cubic yard, for the various kinds of sands, gravels, or clays; and from 6*d.* to 2*s.* for harder materials, rocks, &c., but, in addition, various other matters are to be provided—barrows, planks, wagons, temporary railways, &c.—the present modern practice in moving large quantities of earth is vastly different to what it was in this country thirty years ago, or to what it still is on the continent, more particularly in the greater distance to which the material is carried; these several distances between the excavations and the points of depositing them, either into embankment or to spoil, must be ascertained from the longitudinal section, and a careful examination on the ground—these distances are technically called *the lead;* for distances under a quarter of a mile, the prices are higher, in proportion, than for longer distances. Taking the average description of soils, and the average distances, 1*s.* per cubic yard may be taken as a covering first estimate, upon the whole number of cubic yards of excavation or of embankment, whichever may be the larger quantity shown upon the section. The quantities of earthwork in a railway, on an average per mile throughout the whole distance, might be taken as a characteristic of its cost, so far as mere construction went, independent of carrying establishments, stations, and land, over which items the engineers seldom had control. Mr. Vignoles said it would be very interesting to have an abstract of the quantities and cost of the earthwork, distances carried, &c., on all the railways, and indeed of all other items of the works, as actually executed; they would become valuable precedents for future estimates, particularly if accompanied by explanations of the circumstances under which the operations were carried on. The great haste with which many of the railways were executed, while the late powerful excitement lasted, had added greatly to the cost, by raising the price of labor. Mr. Vignoles stated that he had already given some such abstracts of the railways that had been executed by him, or under his directions, and he was prepared to give more, and he hoped that other engineers would follow his example, as it could not but be very satisfactory to the proprietors of the different concerns, as well as a justification to the engineers themselves, and to the directors, that they could go into the minutest detail of expenditure. The Professor then gave abstracts, in round numbers, of the quantities of earthwork on many of the principal lines of railway, as well as could be ascertained from the sections. He mentioned the North Union Railway, twenty-one miles long, with 125,000 cubic yards of earthwork per mile, at an average cost of 10¾*d.* per yard, including all extras and contingencies. The Midland Counties, 57¾ miles, with 100,000 cubic yards of earth per mile, at an average cost of 13*d.* per yard, including slips and all charges, the soils nearly the same in each, and the average lead nearly alike—viz., one mile—attributing the difference to the great haste and great demand for labor in the latter. The mean of these would be now a fair estimate.

Having estimated for the cost of obtaining the artificial bed of the railway, the next item would be the *Bridging and Masonry*—that is, to restore the previously existing communications of roads, canals, or other railways, the passage of rivers, watercourses, &c. &c., by viaducts, aqueducts, ordinary bridges, culverts, drains, &c., and often by heavy retaining and breast walls. Under this head came the bridges of brick, timber, or iron;—in very marshy countries, where the foundations are likely to be bad, and the drainings liable to be affected, timber may be resorted to, and used in the shape of piling, with cross beams to sustain the rails across the openings, avoiding thus the cost of arches, abutments, and wing walls. The ascertainment of the several superficial or cubic quantities in each of these different constructions, is a matter of simple mensuration from the working drawings. The attachment of prices to these, in all their various details, with sufficient accuracy, depends on the mature judgment and experience of the engineer; and it is by a long course of careful study and observation that the young student, in his employer's office, and on his works, can alone hope to acquire this knowledge. It was but too common, in making estimates, to fall short in this item, particularly in the number of occupation bridges, which owing to the complicated holdings, improvements, &c., had to be provided for to a vexatious extent, or bought off. The masonry is generally in proportion to the earthwork, and in many cases has happened to be of nearly the same amount of cost. The average number of bridges on a main line of railway might be taken at five for two miles. Diversions and embanked approaches of roads, gravelling or metalling the new surfaces. and the contingent operations, should be separately calculated. They are included under the head of fencing, of earthwork, or of bridging, or kept as a distinct item, according to the practice of the engineer, but they form a large sum, varying from 100*l.* to 500*l.* per mile, according to circumstances, and, in preliminary estimates, are too often omitted, or are put into that refuge for all deficient items—contingencies.

The item of *Upper-Works* in general, or *permanent way*, had been gone into so fully in the recent lectures, that it was not necessary here to do more than mention it, as forming a leading point in considering estimates. It is usual to add 10 per cent. upon all the items of the estimate, properly belonging to the engineer. Besides these were the preliminary expenses of surveys and Act of Parliament. The management, including cost of conveying, &c., and all salaries and expenses of direction, office, engineers, solicitors, &c. &c. Then came the expenditures on the stations, engines, carriages, repairing and building shops, fittings, and all the carrying establishment necessary for passengers, also for goods and for ware houses, wharfs, and other accommodation. It was in them the heavy extra expenditure of railway capital mostly went, and which, in the early stages of the railway system, could not be properly judged of. By way of summary, Mr. Vignoles said he would give, in his next lecture, the actual cost of one or two lines of railway which had come under his direction, and which might be useful by way of reference in making out estimates on other occasions, though the construction and working of railways must be regulated on much more economical principles than had hitherto been the case, or no more of them would be undertaken.

(To be continued.)

### *On Bridges.*

At the ordinary general meeting of the Royal Institute of British Architects, held on Monday evening, the 15th May last, Professor Hosking illustrated and explained his proposal to improve the design of arched bridges, by the introduction of a transverse arch, groined into the longitudinal arch, or series of arches; and showed the effect of this and other suggestions he has made for the improvement of bridges, in a design for remodelling Westminster Bridge.

Mr. Hosking began by stating that the closely attentive consideration of the subject of bridge designing and building, rendered necessary by his engagement with Mr. Weale, to supply a practicable treatise for the extensive work on the Theory and Practice of Bridges, now lately published, gave rise to some suggestions of improvements in design and construction, which he believes to be novel, and knows (as far as he is concerned) to be original.

His object, on that occasion, was to explain and illustrate the more important suggestions he had made, that they might not be misunderstood, and might be more extensively known than they were likely to become whilst they rested within the covers of a professional library book.

On a former occasion, in that room, he had made some remarks upon the subject of bridge building generally, and had urged that the piers of bridges were built of much greater substance in thickness, than was necessary for either safety or agreeable effect; that they might, therefore, be greatly reduced in bulk, both for economy and for their effect upon the water way, and without diminishing their efficiency. It had been objected to him, however, at that time by some of the members—with the too common fault of architects, who would sacrifice use to effect, instead of compelling the useful to be effective—that his proposal tended to destroy the due proportion in appearance of the pier to the opening. The eye that had been accustomed to the bridges upon the Tiber, at Rome, of which the piers are rarely less than one-third the span of the larger of the two arches resting upon them respectively, would be offended by the absence of that proportion of solid to void in London and Waterloo Bridges, in which the same relation is but one-sixth; whilst the eye accustomed to the bridges upon the Thames, at London, would condemn the bridges at Staines, and the bridges of Jena and Neuilly, on the Seine, of which the piers are but one-eighth, one-ninth, and one-tenth of the span of the arches resting upon them. Nor have we yet reached the limit to which the diminution of proportion may be reduced with safety and good effect. Further to justify such further reduction, was one of the ends to be answered by the arrangement he was then to explain, which has the effect of reducing also the weight to be sustained by the piers of an arched bridge. The idea had occurred to him, and he had matured it so far as to be able to speak of it with confidence on the former occasion alluded to above, but as he was then unprepared with illustrative diagrams, he had thought it better to withhold it for the time.

The proposed improvement consists in groining a bridge arch, or in carrying a groined transverse arch through the length of a series of arches; and the advantages derivable from this plan consist in lessening the weight of the bridging constructions; in reducing the thrust upon the abutments, and, consequently confirming the stability of both arches and abutments; in diminishing the liability of the bridge constructions to vibrate under the action of pulsating or of rolling bodies; and, generally, in greatly reducing the cost of construction.

The weight is obviously lessened by the difference between the massive haunches of the main vaults, and of the requisite backing to them through the extent of the transverse arch, and the comparatively light inner transverse arch, which being of slight span, may be of stones of much less depth than the main vaults require; the thrust of the main vaults is clearly dissipated throughout so much of the width of the bridge as the inner transverse arch occupies, and so that if the latter occupy the proportion of the width that might be given to it, the abutments of the bridge may be reduced to mere wing walls; the vibrations arising from the traffic upon the bridge are checked at the groin points as at nodal points in a vibrating cord—and the groins lie directly under the carriage road where alone any action that could be felt in a heavy mass of masonry can arise;—and the cost of construction is reduced by the reduction in quantity of the materials in the piers and in the vaults—by the reduction of labor required for the softer stone available for the inner transverse arch, and by the lighter centering sufficient for the same.

He had endeavored to illustrate his suggestions by applying what he proposed upon a compartment of London Bridge, as a familiar instance, but without any idea of reflecting upon the existing condition of that magnificent work. [Here Mr. Hosking explained the diagrams, which were merely enlargements of the plate which illustrate the same subject in the Treatise on Bridges.]

The only indication of such an arrangement as that he suggested, in any existing work with which he was acquainted, is in Perronet's Bridge of St. Maxence, where low arches are introduced over the divided parts of the piers transversely of the bridge, to take the springings of the great longitudinal arches, but these have neither the intention nor the effect of what is proposed, and are a source of weakness and expense, rather than of economy and endurance. [The diagrams which illustrated this, showed that the transverse arch was low and flat, instead of rising to the full height of the great longitudinal arches, and must, therefore, exert a great thrust upon the divided portions of the piers which abut it; and as the vaults spring upon the backs of these transverse arches, there is no relief either in thrust or weight by groining.]

He was well aware that the suggestion he had made was exposed to controversy, upon the presumption that the transverse arch may not have sufficient abutment within the length of a pier, transversely of the bridge, and as the theory of the groined arch has not been satisfactorily determined, if, indeed, it has been really investigated, he must claim to refer to experience, and assert upon example, that the inner arch, as he had drawn it in the diagram, was superfluously abutted. Under any circumstances, indeed, it can be only a question of greater or less span of the inner transverse arch, with reference to the abutments afforded to it by the springings of the outer and greater longitudinal arch to which it is groined, since there can be no question but that if the abutments are sufficient to restrain the arch, the opertion may be safely carried out. In the example, the transverse inner arch occupies but half the length of the pier, leaving the minimum abutment equal to half the span of the arch, with the means of increasing it to almost any extent, by raising buttresses upon the heads of the cutwaters.

Numberless instances exist of arches of far less rise in proportion to their span, than the present example shows, abutted only by the piers on which they rest, or rather by a substance upon their haunches extending only to the thickness of their piers; the piers being far less in proportion to the span, than in the example, whilst the proportion of abutment to span should increase, as that of rise to span diminishes. Trajan's Bridge over the Tagus, at Alcantara, the Pons Palatinus, or Ponte Rotto, upon the Tiber, at Rome, the ruins of Augustus' Bridge, at Narni, are cases in point, and every cathedral chapter-house in England, in the pointed style of architecture, and every arcaded cloister, furnishes another instance to the same effect.

Another question may arise as to the sufficiency of the area of the bearing surface upon the piers at the springing of the arches, for very much less is allowed, than it has been usual to give in such cases.

Perronet calculated upon experiments, that the stone of which his Neuilly Bridge was built, is capable of sustaining twelve times the weight imposed upon it in the piers of that bridge. The area of the bearing surface of the piers of Neuilly Bridge, is about one-tenth of the area covered by the two half arches resting upon the piers respectively. In the supposed case, the weight of the superstructure, as compared with Perronet's, is diminished by the introduction of the perforation in the arches, longitudinally of the bridge, and the stone of which London Bridge is built, being stronger than the stone used by Perronet, in a much greater degree than the difference of their specific gravities would indicate; the substance of the arches built of the stronger stone, may be relatively reduced. These circumstances operate to such an extent, that the weight of the superstructure is reduced, as compared with Perronet's work, nearly, if not quite, one-fourth; and as twelve times the sufficient strength is, besides, very much more than enough for the extremest contingencies, it is not too much to assume that the area of bearing surface of the arches at the springings, or on the piers, may be taken at one-fifteenth the area covered by the two half-arches. In justification of this assumption, it may be added that, without the same reason for it, but with flatter arches, certainly, than at Neuilly, Perronet made the area of the bearing surface upon the piers at the springings of the arches in the Bridge of St. Maxence, and with the same stone of Saillancourt, less than one-seventeenth the area in horizontal section of the space, covered by two half arches.

But the granite used in London Bridge, is of considerably more than twice the strength of the Saillancourt freestone in the bridges of Neuilly and St. Maxence, and upon which Perronet's experiments were made; and, therefore, the area of the bearing surface of the arches at the springings, may be one-thirtieth the area in horizontal section of the space covered by the two half arches resting upon any pier.

This is the proportion allowed in the case supposed, and the area of bearing face is upon the calculations regarding Neuilly Bridge, and having reference to the different powers of resistance of the two kinds of stone, more than enough for ten times the load it would be called upon to bear. Having reference, however, to other instances of the powers of stone to resist crushing pressure in the central pillars of some of the cathedral chapter-houses, it may be safely concluded that experiments upon small pieces of stone give results much within the strength of the material in the block; so that having counteracted the tendency of the traffic upon a bridge, to induce vibration in the structure by the introduction of the deep transverse arch, groined to the flat longitudinal arches; it is believed that the bearing surface at the springings of the arches, and, consequently, the piers under them, might be reduced, not merely with perfect safety, but with great advantage, very much beyond what he had now endeavored to justify, in the example before the meeting.

Mr. Hosking then proceeded to explain the advantages of corbelling out the parapets on bridges, according to the method he has proposed in his Treatise on Bridges; and read some passages in explanation of them, from that work; and showed, by diagrams, the manner in which the work might be composed constructively, and, as to decoration, either plainly corbelled, or enriched faces to the parapet. He then resumed his remarks, and stated that in closing his observations upon the design and arrangement of bridges, he could not avoid noticing a pressing instance of an important work, within the personal knowledge of all who live in, or have ever visited London, rendered by circumstances which have grown up around it, altogether unfit, both in its design and arrangement, for the position it occupies. In September last, he wrote, in the *Treatise on Bridges*, as follows:—

"It is difficult to close a *Treatise on Bridge Architecture*, without remarking the increased unfitness of the present superstructure of Westminster Bridge. The arches spring at a level very little above that of low water, where the tide rises and falls from 15 to 18 feet, so that the water-way is nearly 50 feet, or about one-sixteenth less at the height of ordinary spring tides, than at the level of low water in the river. The arches contract the way for navigation much more than it is at all necessary they should, even upon the present piers, and there is more than twice the height from the soffits of the arches to the level of the roadway, than there need be; the parapets are alike offensive, by their great height from the roadway, and by their ugliness in detail, and injurious by the drafts induced by the perforations of the balustrades; and the solid counterfort buttresses over the cutwaters, and their inclosed and cupolated heads, add needlessly to the weight upon the piers. The bridge is unfortunately near to the magnificent buildings of the Houses of Parliament, and its great height renders this proximity more injurious than it might otherwise be. In all probability some abatement will be made of the height of the bridge in the process of the works now (1842) in hand for securing the pier, and, doubtlessly, the same good sense which opened a view of the river from Blackfriars' Bridge, will open the magnificent prospect Westminster Bridge can command, by substituting parapets, which shall be truly so, for the perforated walls which now hedge in the road-way; but the arches will still continue to render the navigable water-way narrower and more inconvenient than even the multiplicity and thickness of the piers, or the condition of the work, impose. The character of the work, too, will still remain inconsistent with its position at Westminster. It ought, therefore, to be completely remodelled. As the piers are now in process of being repaired and secured, and so as to be free from any danger, founding new piers is out of the question, and the piers cannot be reduced in number without imposing additional weight on those which may be left; a condition which the original defective founding, and the badness of the original structure, forbid. The whole of the superstructure might be removed, however, and the piers being carried up from the level of the present springing to that of high water, of the substance which the cutwaters now show within that range, flat pointed arches might be sprung at that level, and the whole superstructure re-constructed in accordance with the prevailing style of the Abbey, Hall, and Palace of Westminster. The longitudinal central groining herein before proposed, might well be adopted with excellent effect, lightening the upper works, relieving the thrust of the arches, and greatly economizing the reconstruction, as the old stone would work in well for this purpose, whilst the faces and main vaults were of new. The widening of the water-way, by the removal of the springings of the arches out of the water, would allow characteristic abutments to occupy the space now taken up by the two first arches of the series of thirteen, as well as the site of the two small land arches, without affecting the current, injuriously; and as the flat, pointed arch would give much more freedom to the navigation than the semi-circular arch affords, independently of the increased lateral space in every bay, the vertical head-way might be taken at an average of that now afforded by the central group. Moreover, the increased space at the approaches obtained by obliterating the useless land arches, would allow the accesses to the bridge from the low ground on either side to be greatly improved, and the ascent eased by dividing them to the right and left over the abutments, and so to distribute the rise over a longer space, and give the means of dividing the going and coming traffic."

These observations, continued Mr. Hosking, coincide in a very remarkable degree, with those upon the same bridge, in the report lately presented by Mr. Barry, to the Commission on the Fine Arts, in connexion with the House of Parliament. It was true that his suggestions stood alone in the particulars in which it was almost certain they would be peculiar; as it regards the introduction of the inner transverse arch groined to the main vaults; the increase of the span of the arches upon the same piers, (for he did not understand Mr. Barry's report to contemplate that) and in widening, winding and dividing the approaches for the double purpose of use and delight. It was quite clear, however, that as his remarks were written in September of last year, and—with the wood-cut illustration of the subject which appears with the text—printed in October, though not published until February of this year, he might claim some credit for having taken the same view of the subject that had already, he doubted not, presented itself to the mind of their eminent contemporary, whilst it might be held to strengthen, in some degree, the view they had both taken, that it had occurred to both Mr. Barry and himself, without communication or knowledge, indeed, of each other's doings, to support it by the same train of argument.

Civ. Eng. & Arch. Journ.

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## Gen. Pasley *on crossing Railways, by common roads at the same level.*

Railway Department, Board of Trade, 17th March, 1843.

*My Lord*—In obedience to your Lordship's orders, that I should examine the projected Peterborough branch of the London and Birmingham Railway Company, and report whether the unusually numerous level crossings of turnpike, parish, and other roads intersecting it, as well as the single line of rails proposed, will be objectionable on the ground of public safety, in the event of this branch being carried into effect; I proceeded, on the morning of the 14th instant, to Blisworth, this being the point where it is to commence; and from thence I carefully examined the whole of the line proposed as far as Peterborough, which occupied two days, because it was necessary for me to cross the Nene continually from one side to the other by a circuitous route, sometimes along the left, and sometimes along the right bank of that river.

Mr. Bidder, the second engineer of the proposed branch, in the absence of Mr. Robert Stephenson, having lent me an ordnance map on which he had traced the whole line in red, and having also supplied me with lithographed plans and sections of the same on a very large scale, that will be submitted to Parliament, I was enabled to trace it on the ground to great advantage; and I consider the line chosen between Blisworth and Peterborough to have been extremely judicious. It will descend the valley of the Nene, occasionally crossing that stream, and never receding from it more than about a mile and a quarter, to cut off the sinuosities of the river, which flows with a moderate descent through a valley varying in width, but nearly level; so that the proposed line will have the advantage of requiring few embankments and cuttings, and of very moderate height or depth, and only one tunnel, of 688 yards in length, in crossing the high ground to the south of Stibbington. Hence the level of the proposed railway will differ so little from that of the natural ground over which it is to pass, that it may be executed at much less expense than other railways in general, provided that the Company who is to form it be allowed to use level crossings for the roads that will be intersected by their line, which are so numerous, that if the bridges over all, or most, of those roads be made a *sine quà non*, it will be a complete veto to the undertaking, because, one of those bridges might cost nearly 7,000*l.*, including not merely the principal arch itself, but the approach to it, whether consisting of earthen embankments or of brick arcades, especially in those parts where the railway may require to be raised five or six feet to guard against the inundations which occur from time to time in the valley of the river Nene.

In order to judge how far level crossings may be dangerous to the public safety, I have repeatedly passed along the Northern and Eastern Railway, from Stratford to Bishop Stortford, which may be considered as a prototype of the Blisworth and Peterborough branch, as it ascends, first, the valley of the river Lee, and then that of the river Stort, in the same manner that the latter will descend the valley of the river Nene; and, in consequence of this advantage, the Northern and Eastern Railway has been completed with very little labor of earthwork, but it abounds in level crossings, there being no less than 19 or 20 in the space of 28 miles, at all of which, except private or occupation roads, gates have been erected shutting across the road, and only opened for passengers when required, at which period they are shut across the railway. This is done by a gatekeeper living in a cottage on the spot. The trains of the Northern and Eastern Railway never slacken their speed in passing those points, unless the gates should be shut across the railway, which are sufficiently conspicuous by day, and rendered so by a red lamp at night, which is a signal to stop. This railway has been opened, though not to the whole of its present extent, for about two years and a half, and no accident has ever occurred at any of its numerous level crossings. The example of this line is, therefore, a sufficient proof that level crossings on a railway are perfectly safe, if steady gatekeepers be employed at all of those turnpike, or other public roads; and the management of the Birmingham Railway is so very perfect, and all the enginemen, policemen, and others in their employment, so competent and correct in the execution of their duty, that I see no danger whatever in allowing them to have as many level crossings as they please in the proposed line between Blisworth and Peterborough, which will not be more numerous in proportion, than on the Northern and Eastern Railway, for the number will be about 28 in 47 miles, of which the greater part are little frequented; whilst at the crossings of the most important public roads, it is proposed to have stations where the trains will stop; indeed, on a review of railway accidents by collisions, there have been much fewer at level crossings than on the regular lines of rails, and the worst of the former occurred when the custom of shutting gates across the railway prevailed as a general rule; the danger of which having become evident, it has since been abolished. In respect to accidents to foot passengers at level crossings, these have not occurred, nor can they ever occur, except through the extreme imprudence, recklessness, or intoxication of individuals.

Upon the whole, I feel it my duty to certify that the proposed level crossings on the Blisworth and Peterborough line are unobjectionable on the ground of public safety, provided that there is a proper gatekeeper stationed at all the crossings of turnpike, parish, or other public roads; and I can see no necessity for slackening the speed of the trains at every such crossing, except for a limited time after the first opening of the proposed branch, which is always prudent in new railways.

I before mentioned that it is proposed to lay down only one line of rails between Blisworth and Peterborough, but the intention is to make the permanent roadway wide enough to admit of a second line of rails hereafter if required. In very short lines, in which the trains may go from one end to the other, and return again without meeting or crossing each other, even if there be a considerable traffic, no chance of collision can occur; but I apprehend that the proposed Peterborough branch will be too long to be worked in this manner, unless the traffic were very small indeed, and, therefore, that the up and down trains will have to cross each other at some central station, where there must be a double line of rails for that purpose. This may be effected without the smallest risk of collision by good arrangements, for which the Directors and officers of the London and Birmingham Railway Company may be trusted, and which are so obvious, that I shall not enter into details. Indeed it appears to me that there is so little difficulty in this matter, that it might be accomplished with perfect safety to the public, even without the electric telegraph, which, however, the Company proposes to lay down along the whole of this branch, and which will be still more satisfactory, because if any accident should occur to prevent one train from reaching the central or junction station in proper time, the circumstance may be made known at that station, to do away with all suspense; and, if such accident should entirely stop, instead of merely delaying, the train, it may be got into a siding, of which there will, no doubt, be several, and when this is made known by telegraph, the trains moving in the opposite direction may proceed without being stopped also.

After having finished my inspection of the proposed branch from Blisworth to Peterborough, I returned by way of Huntingdon, Cambridge, Chesterford, Newport, Bishop Stortford, in order to view the ground over which it is proposed that the extension of the Northern and Eastern Railway shall eventually pass: and one thing is certain, that, if this extension should ever take place, no passengers from Peterborough, or the vicinity of London, will go by the circuitous route of Blisworth; so that the branch which forms the subject of this letter, will be confined to the traffic of the valley of the Nene, along which it is to pass. I have the honor, &c.,

(Signed) C. W. Pasley, *Major-General*,
Inspector General of Railways.

The Right Hon. the Earl of Ripon, &c. &c. &c.

Railway Magazine.

## *Preserving Timber.*

Payne's Patent for preserving timber from the ravages of the dry rot, insects, &c., is now likely to be brought into extensive operation; the process consists of impregnating timber with a solution of the sulphate of iron, and forms an insoluble chemical preservative, and by the process adopted, impregnates the timber to the very centre; this is effected by placing the timber in large iron tanks with the solutions, and then first exhausting the air, and afterwards readmitting it, and then using a force-pump, with a pressure of 200 lbs. on the square inch, to force the solution into the heart of the wood, which it does very effectively. Iron, as a preservative to timber, has long been known, and it is now, through the ingenious process adopted by Mr. Payne, likely to become very extensively adopted. The Company is now preparing the timber to be used at Claremont, for the royal stables, by command of the government.

Civ. Eng. and Arch. Jour.

# Architecture.

## *The Principles of Landscape-Gardening and of Landscape-Architecture applied to the laying out of Public Cemeteries and the Improvement of Churchyards; including Observations on the Working and General Management of Cemeteries and Burial-Grounds.* By J. C. Loudon, F. L. S., H. S., &c.

(Continued from page 54.)

### II. THE LAYING OUT, BUILDING, AND PLANTING OF CEMETERIES.

Having shown the use of cemeteries, we shall next consider the mode in which the ground should be laid out or arranged, with reference to these uses.

The *situation* of cemeteries, as they are at present used, that is, interring several bodies in one grave, and placing coffins in vaults. ought always to be at a distance from human dwellings; but if only one coffin were to be placed in each grave, and that grave never again opened, but the cemetery when filled, used as a public garden, its situation might be regulated solely by convenience; and, in general, the nearer the town, the more desirable it would be, both as a burial-ground and a promenade. Cemeteries, as at present used, ought to be in an elevated and airy situation, open to the north, but with a south aspect, that the surface may be dried by the sun; rather than with a north aspect, where the surface would be moist during the winter months. If the surface be even, it will be more convenient for interments, than if it were irregular, whether by broken ground, rocks, or undulations. It should be as near the great mass of the population for which it is intended, as a due regard to their health will permit, in order to lessen the expense of carriage, and shorten the time of the performance of funerals, and of visits by the living to the tombs of their friends; it ought to be conspicuous at a distance. because, from its buildings and tombs, it will generally be an ornament to the surrounding country, and an impressive memento of our mortality; and the outer boundary ought to be regular and simple. in order that it may be short, and, consequently, less expensive than if it were circuitous.

The *soil*, for reasons which we have already noticed, ought to be dry to the depth of 20 or 30 feet, or capable of being rendered so by underground drains. It ought not to be generally rocky, at least where deep graves are to be dug. As in decomposition, a considerable quantity of moisture (sanies) is exuded, the greatest care ought to be taken not to form a cemetery over a stratum of soil which contains the water used in the neighborhood for drinking. Not to mention numerous instances in London, as noticed in the *Report on the Health of Towns*, there is a churchyard near Kirkaldy, in Fifeshire, with a perpetual spring immediately without the boundary wall, the water of which, passing through a stratum under the graves, is said to be contaminated; and the burial-ground of St. Peter's Church, Brighton, cannot be used as such, on account of the proximity of the chalky stratum which contains the water that supplies the wells of the lower part of the town.

In situations where, from the flatness of the country or the nature of the soil, there is not an opportunity of draining to a great depth, care ought always to be taken to carry off as much as possible of the surface water by shallow underground drains placed under the roads, and under the gravel walks and green paths which separate the lines of graves. No drains can be made under those parts of the surface in which graves are to be dug, for obvious reasons. Many details of this kind, which need not be entered into, will readily occur to the practical man.

The prejudices of the living, in every country, are in favor of a gravelly, sandy, or chalky soil; and in such soils draining is not required. In strong, clayey soil, like that of most of the London cemeteries, decomposition does not take place for a very long period, the fleshy part of the bodies being changed into adipocere.

The *extent* of a cemetery must, of course, depend on the population for which it is intended; the probable increase or decrease of that population; and whether one, or more than one, interment is to be made in the same grave. The data on which to form the necessary calculations, are, that the average outside dimensions of a grave are 7 ft. by 3 ft. 6 in.; that the average dimensions of a grave, where a number of them are supposed to have grave-stones, are 8 ft. by 4 ft.; and that the average deaths in a healthy population in the country are 2 per cent., and in crowded towns and cities 3 per cent. per annum. Thus, 20 graves will be required per annum for a rural population of 1000, and 200 per annum for a population of 10,000. An acre will give 1361 graves, which will afford a supply for nearly seven years; and three acres will serve for twenty-one years. At this latter period the town will probably have increased on the side next the cemetery, when the additional ground should be taken at a greater distance, and the old ground, when fully occupied, may be sprinkled over with trees, to be eventually used as a place of recreation for the living. The calculations, however, will be considerably different, if we suppose that all the graves are to be without headstones, and, consequently, no longer than is necessary to admit the coffins. For this purpose, the average width of the grave at one end may be 2 ft., and at the other 20 in., and the length 6 ft. Taking the greater width, this will give 12 square feet to each grave, which will give 3630 grave to an acre. These graves in the London cemeteries are dug 15 ft. in depth, and ten coffins of poor persons are deposited in them. The common charge is 25*s.* for each coffin, or at the rate of the enormous sum of 45,375*l.* per acre. In some cemeteries, as many as fifteen coffins are deposited in one grave, the depth in that case being 20 or 25 feet. We could name a cemetery in which forty-five coffins, we are assured, have been deposited in one grave.

The situation, soil, and extent being fixed on, the next consideration is the *boundary fence,* which ought to be such as to insure security from theft, and favor solemnity by excluding the bustle of every-day life, while a view of distant scenery is admitted to produce a certain degree of cheerfulness, and dissipate absolute gloom. In an open part of the country, where there are few buildings or public roads, an iron railing may be employed as a ring-fence; but, in a populous neighborhood, a wall 10 or 12 feet high, strengthened by buttresses carried up above the coping, so as to give the wall an achitectural character, may be preferable. The buttresses may be of two kinds: ordinary ones, merely for strengthening the wall, or forming piers to panels of open iron railing; and, in the case of cemeteries not laid out in beds or panels, higher and more massive piers rising conspicuously above the others, at regular distances, to receive stones having cut in them the numbers and letters used as indexes to lines for ascertaining the situations of graves, in the manner which will be hereafter described. The numbers and letters alluded to, are at present in most cemeteries painted on the brickwork, which has a mean temporary appearance; or they are put on stones or labels of cast iron inserted in the soil, and rising only an inch or two above it, which are liable to be disturbed by the moving of the ground. Though we entirely disapprove of this mode of laying out a cemetery, yet, as it is generally practiced, we have thought it right to keep it in view. Where economy is an object, a hedge and sunk wall may be used as a boundary, and the best plant for the hedge is the common holly. There ought to be one main entrance; and, if the situation admits of it, a second entrance, for the admission of workmen, carts, &c., necessary for carrying on the executive part of the cemetery.

In *laying out the interior*, the system of roads and walks, the drainage, the situation of the chapel, or chapels, and the arrangement of the graves, and of the marks which in large cemeteries, as at present laid out, are necessary, at the angles of the squares, require to be taken simultaneously, and also separately, into consideration. There ought to be at least one main road, so as to allow of a hearse having ready access to every part of the grounds; and from this road there ought to be gravel walks into the interior of the compartments formed by the roads, walks, and the boundary wall; and, from these gravel paths, ramifications of narrow grass paths, so as to admit of examining the graves in every part of the grounds, without walking over any of them, and thus insure respect for the dead. We have already observed that all the drains that require to be made must be under these roads, walks, and paths, so as not to interfere with the graves; and the ranges of situations for graves must be determined before the roads, walks, and green alleys are fixed on, otherwise there might be a waste of ground. To be convinced of the bad effects of the neglect of surface drainage in a cemetery, it is only necessary to walk on the grass of that at Kensal Green during winter or spring.

The first point to be attended to, according to the present system, unless the cemetery should be a small one of only an acre or two, is to devise a system for *throwing the interior into imaginary squares or parallelograms,* which shall be indicated by numbers and letters on the boundary fence, and by marks inserted in the ground at their points of intersection. In cemeteries of moderate dimensions, more particularly if the form be rectangular, the marks at the intersections of the squares may be dispensed with; these intersections being readily ascertained when it is desired to find out the precise situation of any grave, by stretching lines across the cemetery from the letters and figures on the boundary fence. For example, suppose fig. 1 to represent a cemetery of five acres, with the letters A, B, C, &c., marked at regular distances on the end walls, and figures 1, 2, 3, &c., at the same distances on the side walls; then, by stretching one line from B to B, and another from 2 to 2, &c., the intersections of the strings will give the points B 2, C 2, &c.: but supposing the surface of the cemetery to be very hilly, or that it is thickly studded with tombs or trees, then, as the lines could not be readily stretched so as to give the points B 2, C 2, &c., with perfect accuracy, a stone, or mark of cast iron, is inserted when the cemetery is first laid out, in each of the intersecting points, with the letter and figure on it, as shown in the diagram fig. 1, at B 2, C 2, D 3, &c. At every other point of intersection throughout the cemetery, there is a sunk stone, or iron, inserted, with the letter which stands at the ends of the long lines, and the figure which stands at the ends of the cross lines, as shown on a large scale in fig. 2. Thus in the diagram fig. 1, we should have the squares A 1, B 1, C 1, D 1, &c.; and A 2, B 2, C 2, &c. The use of these squares is to enable the sexton to ascertain and point out, at any future time during the existence of the cemetery, the precise spot where any interment has taken place. For example, required to see the grave of T. W. On turning to the index of the register book of names, T. W. is found to have been interred in the square B 4. Now, on turning to the map book of the cemetery, in which every imaginary square into which the cemetery is parceled out, is laid down on a large scale, the position and dimensions of the grave will be found delineated according to the scale; and then, by taking the dimensions from two of the sides of the square and applying them to the ground, the exact position of the grave is found, even though the grave mound should be obliterated. Now it must be evident that it would be exceedingly inconvenient to have the stone marks fall into positions where buildings were to be erected, or roads or walks to be laid out; and hence the propriety, as we have said above, of determining the position of the intersections of the squares, before any other part of the laying out is proceeded with. This is the more necessary in cases where the intersecting points are to be marked by trees of particular kinds, or by an obelisk, or other monumental stone. By using an obelisk or other pillar with four sides, pointing diagonally to the four squares, as at

Fig. 1.

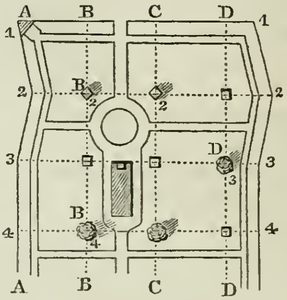
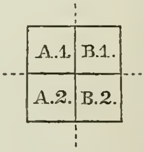


Fig. 2.



B 2, and C 2, in the diagram fig. 1, these stones would not only serve to indicate the intersections of the squares, but to record the names of those buried in each square, if the parties interested thought fit to incur the expense. It is not necessary that all the squares or parallelograms should be of the same size; on the contrary, their dimensions may be varied, so as to suit the ground, the boundary, and all the different circumstances connected with the general arrangement. In some cases the intersections of the squares might be indicated by trees, as shown at B 4, D 3, &c.

It must be confessed, however, that this system of laying out a cemetery into imaginary squares, is a very unsatisfactory one, for the following reasons:—1. It neither admits of a permanent system of surface drainage, nor of grass paths among the graves. 2. From there being no obvious principle of order or arrangement in conformity with which the graves are placed, the general aspect of the interior of the cemetery is confused and unsatisfactory; the graves and tombstones seeming to be put down at random as in common churchyards. 3. A very slight error in mapping the graves may render it difficult, if not impossible, to identify a particular grave, either to point it out to the relations of the deceased; or, when the square is nearly full, for the purpose of avoiding an old grave in digging a new one. Let any one who doubts this, examine the map books in the principal London cemeteries, and ask to see one of the graves indicated in the plan. 4. Unless a head-stone is put to the grave, or some other permanent mark, it is impossible for any person but the sexton to identify it; which circumstance can by no means be rendered satisfactory to the relations of the deceased. 5. No provision is made for paths among these graves, so that, when the squares are nearly full, there will be no mode of getting to any one grave, but by walking over a number of others; which is not only a species of desecration, but, when there are several of the graves having head-stones, must be exceedingly inconvenient.

A much better system, in our opinion, is to lay out the ground in what may be called double beds with green paths between, in the manner to be described in a future paragraph, which has an orderly appearance, admits of a permanent system of surface drainage, requires no mapping, and enables the friends of the deceased to recognize the grave they wish to see, without troubling the sexton or any one else. This laying out of the ground in double beds need not be so executed as to have a formal appearance, though it should be sufficiently distinct to give what, in the language of art, is called the expression of purpose, and thus give the lawn of a cemetery a different character from that of the lawn of a pleasure-ground. The double beds may be slightly raised in the middle, so as to slope to the grass paths, and the surface of these paths, if only 3 in. below that of the beds, will be a sufficient distinction, when the whole is near the eye; while, at a short distance, the difference between the beds and the paths will scarcely be perceptible. We mention these things to anticipate objections on account of the supposed formality of this plan. Under every green path there may be a tile drain, which will render it as dry as a gravel walk. The path will answer if only 3 ft. wide, because, in carrying a coffin along it shoulder high, that space is sufficient; but 4 ft. is preferable, as admitting of carrying a coffin by hand-spokes. Where the hand-bier, to be hereafter described, is used, a 2-feet path would be wide enough.

In making arrangements for the *situations of graves,* regard must be had to the wealth and taste of the persons who will probably use the cemetery, and the proportion of situations for sumptuous tombs and monuments adjusted accordingly. At the same time, we should mark no part of the ground as exclusively devoted to any class of society, of graves or of monuments; nor should there be any part in which a monument might not be erected. In general, we would form a broad border, say from 12 ft. to 20 ft. wide, along the main roads; a border immediately within the boundary fence, of the same width as the height of the latter; a border from 8 ft. to 12 ft. wide on each side of the gravel walks; and the interior of the compartments we would lay out in beds or zones, straight or curved, with green alleys of 3 or 4 feet between. These beds ought to be of such a width as to contain two rows of graves, with the head stones of each row placed back to back in the middle of the bed, so as to face the alleys. The necessary width for this purpose is 18 ft.; which will allow 7 ft. for the length of each grave; 1 ft. at the head of each grave, on which to erect a headstone, or other monument not exceeding 1 ft. in thickness nor the width of the grave; and 1 ft. at the end next the walk, for a foot-stone or number. This head-stone or monument, it may be observed, should in no case be built on the soil, but on two brick piers brought up from the bottom of the soil to the surface of the ground, in the manner to be hereafter described.

The directions of the *roads, walks, and green paths,* is partly a matter of necessity, and partly of design and taste. Where the surface of the ground is hilly, undulating, or otherwise irregular, winding roads become necessary; but where the surface is tolerably even, whether a uniform slope or a flat approaching to a level, the choice lies between straight lines and curvilinear ones. The direction of the roads and walks, and, consequently, the whole of the interior arrangement of the cemetery, are thus in a great measure controlled by the character of its surface. In general, straight roads and walks are greatly to be preferred in a cemetery to winding ones, not only as admitting of a more economical occupation of the ground, every grave being a rectangle, and every rectangle being a multiple or divisor of every other rectangle, but as contributing far more than curved lines to grandeur and solemnity of effect. If all the roads cannot be made straight, there ought, if possible, to be one broad and straight road from the main entrance to the chapel. A winding road from the main entrance, with the chapel concealed by trees, has too much the character of an approach-road through a park to a country residence. The roads may vary from 12 ft. to 20 ft. in width, according to the extent of the cemetery; the walks should not be narrower than 5 or 6 ft., nor the green paths than 3 or 4 ft.

The *chapel, or chapels*, ought to be placed in a central and conspicuous situation, so as, if possible, to be seen from all the prominent points of view along the roads and walks. At the main entrance there may be a lodge, or lodges, in which the sexton or superintendent of the ground may reside, and in which also there ought to be an office for the cemetery books and plans, or duplicates of them, and for receiving orders for funerals, &c. One lodge will generally be found preferable to two, because, where lodges are of such a size as to be useful, and are widely separated by spacious gates, they attract attention as separate objects, and do not group together so as to satisfy the eyes as a whole. If there are two separate lodges with intervening gates, the lodges ought not to be higher than the piers between the gates; and they ought to seem rather as massive terminations to the gates than as lodges, in short, as a part of the facade. A striking example of the bad effect of two large lodges, is afforded by the Nunhead Cemetery. The Abney Park Cemetery shows a judicious combination of two lodges with gates between; there is a very good single lodge at the west entrance to the Tower Hamlets Cemetery; and the Kensal Green and West London Cemeteries, afford examples of the lodge and gateway combined in one edifice, the gateway forming an arch through it. Where it is considered absolutely necessary to have two lodges, either to a cemetery or to the park of a country residence, they ought to be combined with the piers of the gates, as at the Abney Park Cemetery; formed into one pile of building with the gateway, as at the West London Cemetery; or one lodge ought to be much larger and higher than the other, in order to form a central mass or axis of symmetry, or, in Hogarth's language, to form the apex of the triangle.

A *yard and sheds* for the cemetery tools, implements, and other cemetery furniture, including a carpenter's shop, may also be conveniently placed near the lodge; but where the cemetery is large there ought to be two or three sheds for planks, barrows, &c., in different parts of the ground. In most cases a reserve ground for spare earth, produced from time to time as brick graves or vaults are formed, for rubbish of various kinds, and for nursing plants, to be placed over the graves when wanted for that purpose, may be requisite. On a large scale, a mason's yard with sheds is essential; unless, which is much the better mode, there should be an establishment of this kind in the immediate neighborhood, by which all the brick and stone work would be done by contract.

On the introduction of *trees and shrubs* into cemeteries, very much of their ornamental effect is dependent; but too many trees and shrubs impede the free circulation of the air, and the drying effect of the sun, and, therefore, they ought to be introduced in moderation. They ought not, as we think, to be introduced in masses in the interior of the cemetery, nor in strips or belts round its margin, unless under very particular circumstances. Every mode of introducing trees and shrubs, which is identical with that practiced in planting parks and pleasure-grounds, is to be avoided, as tending to confound the character and expression of scenes which are, or ought to be, essentially distinct. Independently of the injury done by masses and belts in impeding the free circulation of the air, they prevent the ground on which they stand from being occupied by graves; and though there may be no immediate occasion for so occupying that ground, yet an arrangement which seems to be at variance with, or at least to have no reference to, the purpose for which the cemetery was formed is unsatisfactory. There is evidently not the same objection to single trees or single shrubs; because, in whatever manner they may be placed, still, between and among them, graves may always be formed. There is a specific objection against boundary belts, which is, that they occupy a space that might be advantageously laid out as a broad border for tombs of a superior description, with a gravel walk in front accompanied by another border on the opposite side. For the same reasons that we would not introduce trees and shrubs in masses, we would not, in the case of cemeteries on low or level ground, plant trees which produce bulky heads; but confine ourselves chiefly to kinds having narrow conical shapes, like the cypress, the form of which not only produces little shelter or shade, but has been associated with places of burial from time immemorial. Almost all the kinds should be evergreen and of dark foliage; because the variety produced by deciduous and flowering trees is not favorable to the expression either of solemnity or grandeur. Evergreen needle-leaved trees, such as the pines, firs, junipers, yews, &c., we should prefer; because, when their foliage drops, it produces much less litter than that of broad leaved trees, such as the holly, common laurel, evergreen oak, &c. On very hilly cemeteries we would introduce round-headed trees along with conical shapes, but still chiefly confining ourselves to evergreens, such as the ilex, Lucombe oak, holly, the dark-foliaged pines, &c.

Supposing all the roads, walks, and green paths laid out, or their situations fixed on, and all the beds and borders also laid out, then we would dispose of the trees and shrubs in the following manner. Along each side of most or all of the main roads, whether straight or curved, we would plant a row of trees parallel to the road, and at regular distances, so as to form a running foreground to the interior of the compartments, and to whatever there might be of distant scenery. The kinds should be pines and firs of dark foliage. In roads and walks in the direction of east and west, we would either plant the trees farther apart, or plant narrower-growing kinds, such as the common cypress, the Irish yew, the Swedish juniper, the fastigiate abor vitæ, &c. At many of the intersections of the squares, in those cemeteries where that mode of division is adopted, we would plant provisionary trees, of a kind strikingly different from every other planted in the cemetery, in order to distinguish the angles of the squares at first sight, with the number-stone at their base, to be taken up when it became practicable, or desirable, to substitute obelisks, square pillars, or other monuments, for them. Along the centre of the beds adapted for double rows of graves, we would plant trees or shrubs at regular distances, with the intention that, in this and in all other cases, whatever, except along the main approach from the entrance to the chapel, the trees should be taken up and replanted, or removed altogether, when necessary, so as to suit the position of the graves.

With respect to the kind of trees, we would, with very few exceptions, plant only those evergreens which have naturally dark foliage and narrow conical heads, or which admit of being pruned with little difficulty into such form; because, such forms not only interfere less with ventilation, sunshine, and the performance of funerals, but, more especially when of a dark color, are naturally, from their great height in proportion to their breadth, more sublime than spreading forms; as well as artificially so, from their being classically and popularly associated with places of sepulture. For the main avenue we should prefer *P*ìnus taúrica, *P.* Pallas*iàna,* or *P.* nígricans; if the situation were favorable, the evergreen cypress, or the Juníperus excélsa, found to be a very hardy conical tree; and, if very unfavorable, the red cedar, or the common spruce. The pines and spruces grow rapidly, and admit of being cut into cones as narrow as may be desirable; but, to render this cutting unnecessary, the red cedar, and some of the rapid-growing conical junipers, might be employed. Along most of the gravel walks, and along the centre of the double beds, we would plant, for the most part, only fastigiate shrubs, such as the Irish yew, Irish and Swedish juniper, *J*uníperus recúrva, and some other junipers, and the arbor vitæ, box, common yew, &c. We would not plant, as a part of a general plantation of a cemetery or churchyard, weeping willows, weeping ashes, weeping elms, or trees of that kind; because we think that these trees, being of such marked and peculiar forms, are best adapted for being used only occasionally, for particular purposes; and, therefore, we would leave individuals to select such trees, or trees or shrubs of any other singular shapes that they thought fit, and have them planted over their graves or tombs. Thus, while the general plantations of the cemetery maintained a uniform grandeur and solemnity of expression, the singularly shaped trees and shrubs employed by individuals, would confer variety of character.

A cemetery planted in the manner described, will have a distinctive character, and one quite different from that of any of the cemeteries that we have seen, either in London or elsewhere. The cemeteries, according to our ideas, bear too great a resemblance to pleasure-grounds. That they are much frequented and admired by the public, is no proof that they are in appropriate taste, but only that they are at present the best places of the kind to which the public have access. When our public parks and gardens are extended and improved as they ought to be; when they are ornamented with fountains, statues, immense blocks of different descriptions of rocks, (named) and with models of celebrated buildings, as covered seats and places of temporary repose or shelter; when they abound in singing and other birds, and aquatic fowls, and contain every variety of tree and shrub that will thrive, and many kinds of herbaceous plants; and when they are perambulated, during a certain number of hours every summer's day, by a band of music, as in some of the public gardens in Germany;

then will the necessity, as well as the propriety, of having a distinctive character for cemeteries be understood and appreciated.

The planting of *flowers* in cemeteries is very general, not only in the margin of masses and belts, and in beds, as in pleasure-grounds, but on graves. For our own particular taste, we would have no flowers at all, nor any portion of ground within a cemetery that had the appearance of being dug or otherwise moved for the purpose of cultivation. A state of quiet and repose is an important ingredient in the passive sublime; and moving the soil for the purpose of culture, even over a grave, is destructive of repose.

Nevertheless, as the custom of planting flowers on graves, is common throughout Europe, and of planting them in beds is frequent in the cemeteries about London, arrangements for this purpose must be provided accordingly. We would never plant flowers or flowering shrubs in the margins of masses or belts, or in beds or patches that might be mistaken for those of a lawn or a flower-garden; but, to give them a distinctive character, we would plant them in beds of the shape of graves or coffins, raised above or sunk beneath the general surface, and only in situations and on spots where at some future time a grave would be dug. For example, two graves are seldom dug close together, but an intervening piece of firm ground is always left of width sufficient for forming a grave at a future time; the object being to have, if possible, at all times, firm ground for the sides of a grave which is about to be excavated. Now, on these intervening spots alone would we plant beds of flowers, or of roses, or of other flowering shrubs. When flowers, shrubs, or trees are planted on occupied graves, it is done by individuals according to their own taste. The most highly ornamented cemetery in the neighborhood of London, as far as respects plants, is that of Abney Park, in which as already mentioned, there is a complete aboretum, including all the hardy kinds of rhododendrons, azaleas, and roses in Messrs. Loddiges' collection; and in which also dahlias, geraniums, fuchsias, vebenas, petunias, &c., are planted out in patches in the summer season.

To be Continued.

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## *Description of the Roofs over Buckingham Palace, covered with Lord Stanhope's composition.* By Peter Hogg, Assoc. Inst. C. E.

The mixture invented by Lord Stanhope, and used by the late Mr. Nash, for covering the nearly flat fire-proof roofs of Buckingham Palace, is described in the paper as being composed of Stockholm tar, dried chalk in powder, and sifted sand, in the proportions of three gallons of tar, to two bushels of chalk, and one bushel of sand, the whole being well boiled and mixed together in an iron pot. It is laid on in a fluid state, in two separate coats, each about three-eighths of an inch in thickness, squared slates being imbedded in the upper coat, allowing the mixture to flush up between the joints the whole thickness of the two coats, and the slates being about an inch. The object in imbedding the slates in the composition, is to prevent its becoming softened by the heat of the sun, and sliding down to the lower part of the roof, an inclination being given of only 1½ inch in 10 feet, which is sufficient to carry off the water, when the work is carefully executed. One gutter, or water-course, is made as near to the centre as possible, in order to prevent any tendency to shrink from the walls, and also that the repairs, when required, may be more readily effected. It is stated, that after a fall of snow it is not necessary to throw it from the roof, but merely to open a channel along the water-course, and that no overflowing has ever occurred; whereas, with metal roofs it is necessary to throw off the whole of the snow on the first indication of a thaw. These roofs have been found to prevent the spreading of fires, and it is stated, that on one occasion, to test their uninflammability, Mr. Nash had a bonfire of tar barrels lighted on the roof of Cowes castle. Another advantage is stated to be the facility of repair which the composition offers, as if a leak occurs, it can be seared and rendered perfectly water-tight, by passing a hot iron over it; and when taken up, the mixture can be remelted and used again. The author proposes to obviate the disadvantage of the present weight of these roofs, by building single brick walls at given distances, to carry slates, upon which the composition should be laid; instead of filling the spandrils of the arches with solid materials, as has been hitherto the custom.

The reported failures of this species of covering at Mr. Nash's house in Regent street, and in other places, are accounted for by the composition having been used in one thin coat, laid upon an improper foundation of laths and tiles. The durability of the roofs, which were carefully constructed with good materials, has been, it is contended, fully proved at Lord Palmerston's house, which was covered with the composition in 1807; Lord Berwick's, in 1810; Sir James Langham's, in 1812; the Pavillion, at Brighton, in 1816 and 1823; and nearly the whole of Buckingham Palace, in 1826 and 1829; the latter roofs are stated to be in perfect order at the present time, and have scarcely demanded any repairs since their completion.

*Remarks.*—Mr. Poynter presented a drawing of the mode of setting the pots for melting and preparing the composition, the proportions of which he stated somewhat differently from those given in the paper. Three measures of ground chalk, dried and sifted very fine, were mixed and kneaded up with one measure of tar; these ingredients were melted in an iron pot, set in such a manner that the flame should not impinge too violently upon it. The first or "skimming" coat of the covering being laid on of a thickness of $\frac{3}{16}$ inch, the finishing coat was composed, by adding to the former mixture, three measures of hot sifted sand, well mixing the whole together; the composition was laid on with a tool similar to a plasterer's trowel, but much stronger. Mr. Nash, when he first tried the composition, found that the surface became disintegrated by exposure to the weather; he, therefore, added the slates imbedded in the second coat, and subsequently never used the mixture without them.

Mr. Nixon, in reply to questions from the President and other members, stated, that he was employed under Mr. Nash when the palace roofs were executed, and he could bear testimony to their durability and soundness. The roofs at East Cowes castle, which were covered with the composition in the year 1808, and those of the Pavillion, at Brighton, in 1816, were now in as good a state as when they were finished. The failure at Mr. Nash's house, in Regent street, arose from the roof having been originally composed of mastic, which soon cracked. One coat of the Stanhope composition was spread over it, to stop the leaks, but it was insufficiently done, and ultimately Mr. Rainy had a new roof, properly constructed, with two coats of composition, which had remained sound to the present time. The price of these roofs, when well constructed by the person who did those of the palace,* was about five guineas per square.

Mr. Hogg observed, that the chalk was only exposed to such a heat as would evaporate any moisture it contained. The weight of the two coats of Stanhope composition, including the slate imbedded in it, was about 12 lbs. per superficial foot.

Mr. Sibley considered the Seyssel Asphalte, when carefully laid, preferable to any composition of a similar nature; he had used it extensively, and was well satisfied with it, both for roofing and paving.

Mr. Hogg objected to the use of asphalte for roofing, as it was liable to injury, being of a brittle nature; it was not elastic, and it shrunk from the walls, thereby causing leaks. Lord Stanhope's composition did not possess these faults, and he did not consider that it was superseded by asphalte.

Mr. Moreland had covered the roof of the tread-mill, at Giltspur Street Compter, with asphalte, and had found it answer perfectly. It was laid on in a thickness of ⅜ inch upon roofing boards ¾ inch thick, with canvas nailed on them, with an entire fall of only 9 inches; there was not any appearance of leakage.

Mr. Davidson had caused a school-room to be floored with asphalte, four years ago, and up to the present time, there was no symptom of wearing down, although the stones which were let into the floor, for supporting the desks, &c., were considerably abraded. He believed that the only failures of the asphalte had occurred from the use of inferior ingredients. Gas tar had been used instead of vegetable tar, and in those cases the result had not been successful.

Civ. Eng. & Arch. Journ.

## Mechanics and Chemistry.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

### *On the Strength of Cylindrical Boilers.* By Thomas W. Bakewell, Esq.

A communication from me on the above subject, appeared in the January number of this journal. Prompted by a report on the explosion of a boiler in the steamboat Medora, and composed by Mr.

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* Mr. Millson, No. 6 Frances Street, Tothill Fields, Westminster.

B. H. Latrobe, at the request of the Committee on Publications, for the Journal of the Franklin Institute.

The subject and the error with which it is, by authority, burthened, occasioned my remarks, without any special reference to the Medora's boiler, or the opinions as held by the author of the report, for they (the opinions) are truly orthodox, and would have formed the basis of a report on the same matter, by nearly all, professionally, scientific men.

Many years have not passed, since the advocates of loss of power by the "crank motion" stood on equal ground with their opponents. Fewer years have passed since those who contended for a loss of power by the alternating weight of a lever beam and its appendages, when working through the intervention of a crank, stood on higher ground than those of an opposite opinion; and I well remember the time, when my ideas, especially on the latter branch of the subject, were considered fatally heretical.

I believe I am now safe in saying, that the crank and the lever beam have found their proper places; and most assuredly the cylindrical boiler, will, also, ere long, assume its correct position. I rejoice that my communication, above referred to, has elicited notice. Mr. Latrobe has replied to it in the June number of this journal, which this is intended to meet. The question before us, is, whether steam of a given density, in a cylindrical boiler, exerts a force to rend or part said boiler at any one and every point of its circumference, with a force equal to the pressure which the steam would give, on a space equal to the semi-diameter of the boiler, or a space equal to the quarter circumference—making a difference as 1. to 1.57. The sanctioned and received rule gives the former, while I contend for the latter.

Let it be recollected that the upper and lower points of the boiler, are selected as the points of investigation, merely because they are of easy reference, and that a quarter of the circle only requires to be considered for any one point, as it embraces all the varieties of direction, from vertical to horizontal.

Mr. Latrobe states that "no force oblique to the direction pursued by the body to which it is applied, can operate with its full intensity upon that body; but must expend a portion of its energy upon some other object."

Undoubtedly if that other object be foreign to, and independent of, the body originating the force; but with the boiler, the obliquity, as well as the direct action, must be disposed of within itself, we cannot form the statical triangle without an object distinct from the boiler. When opposing forces are oblique to each other, the primary force governs, and the derivative or resistance, has the obliquity—then, *the required intensity of resistance, to balance a given force, is proportional to its obliquity with that force.*

Mr. L. continues, "Mr. Bakewell's error seems to me to consist in losing sight of this elementary truth, for in using the semi-circumference, instead of the diameter, in his estimate of the pressure, at the extremities of the latter, he omits the resolution of the radial forces into their operative and inoperative elements, and assumes them to act with their full intensity to tear the cylinder asunder, notwithstanding the greater or lesser obliquity of every one of them, excepting the single central one, perpendicular to the diameter."

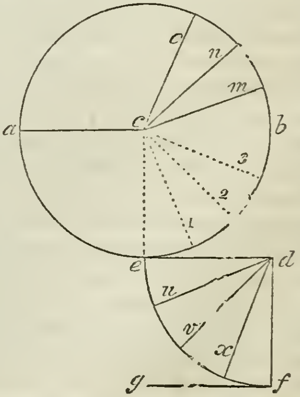
I have not lost sight of this circumstance. The "operative" force at any one point, is, (I suppose) on the received rule, as cosine to radius of the boiler; and for any given space on the circumference, as the vertical base of that space.

Having referred to the crank, permit me to make further use of it, and to observe that this 57 per cent. of difference in our estimates, happens to be the exact amount of mechanical effect which the crank would gain over its present mode of acting, provided the power throughout its circle acted on it at right angles, as it now does at two points only. Or, perhaps, more familiarly to my readers, there is a loss in the present mode of action of 37 per cent. on the 1.57 which *would* be the effect, if, as above, supposed.

As before stated, a quarter of the circle, whether of crank or boiler, is sufficient for illustration of the principle sought. Then let the connecting rod (indefinitely long) from a cylinder, be attached to a crank at right angles, and a series of *other cranks*, project at equal and indefinitely small distances from the same centre through the greater circle; let each and every of the cranks be equally impressed with a given force at right angles to each respectively, then the required resistance on the piston, to oppose and hold these cranks in equilibrio, would be the sum of the pressures on the cranks.

Here we have uniform powers distributed over, and represented by, the greater circle, and conforming to its various directions in *one* direction, represented by a line equal to the semi-diameter, or half stroke, and the obliquities of the resistances and consequent increased intensities, represented by the difference in length inversely (or of motion supposed) between said resistances on the semi-diameter, and the powers on the quarter circle.

The radial action of the steam on any one point, for instance, at the bottom of the boiler, may be viewed in this wise. The boiler may be considered as suspended at *a* and *b*, by the pressures on the upper or opposite half, if you please, (which is true) and the radial force at *e*, acting downwards, through the curved arm, or lever *e*, *a*, the *virtual* length of which is only as *a*, *c*, equal the semi-diameter. By tracing the radial force back and upwards from *e*, by the dotted line *e*, *c*, to its supposed source at *c*, this *virtual* lever is met, and the action becomes apparent; and for each point of radial action on the boiler, shown by the dotted lines, the resting point of the lever so formed, will in like manner be at right angles to such radial force, as 1.*m*—2.*n*—3.0.



Thus we have a series of cranks or levers with varying points of rest, and the force always at right angles. These cranks and their combined effect may be shown concentrated, by having a common centre or point of rest, as at *d*; then *u*, *v*, *x*, represent levers or cranks, *m*, *n*, *o*, respectively, with the several equal forces of corresponding directions at right angles to them.

Now, if the whole quarter circle *e*, *f*, were filled or occupied by cranks under like conditions, the sum of their forces would be expressed by the said quarter circle *e*, *f*, and the required horizontal resistance to balance them, if represented by or on the line *g*, *f*, equal to the semi-diameter, must compensate by intensity what it is deficient in length (or motion supposed).

Mr. L. offers as illustrative of the fallacy of my position, that a ring of iron one inch in width, be filled by a solid disk of some hard body, also one inch in thickness; then divide the disk equally in two parts, and let a wedge be driven with a certain force tending to separate them, or he adds, "what would be better," to introduce steam into the fissure. With steam in the fissure, the disk and ring fall short of making a parallel case. It is plausible, so far as the circular form is preserved, and it is evident that the force to part the ring at top and bottom, would be no more than the pressure on the diameter. But the ring is not under the same conditions as with steam alone; in the latter case, the force acts in all directions with the disk; it is confined to one direction (say horizontal), and it is immaterial whether the steam be prevented from acting upwards and downwards (or largely partaking of those directions), by the interposition of a solid body, or that the force of the steam should be conteracted in those directions by vertical ties. The rule of the force to part, being as the diameter, would be good in either case. The ring near the horizontal ends of the disk, would be in effect converted into a stiff or solid material, losing its flexibility. With the disk, the ring is not under so much pressure outwards near the top and bottom, as with steam, notwithstanding its retention of the circular form; for if the steam were admitted between the ring and the disk—say as far as an angle of 30° on each side the vertical fissure—the top and bottom would be distended, the vertical fissure closed, and the ring cease to be circular; and if the fissure were made of sufficient width not to impede the distention at top and bottom, the ring would be held by the steam acting as above, in equilibrio of an irregular, oval figure.

This last assertion may require some strengthening, which I will endeavor to furnish. Imagine a square, the upper and lower sides of sheet iron, and the vertical sides of strong cast iron, and all the sides may be supposed of one inch in width, as with the ring; then subject the square to the action of the steam. If the upper and lower sides were perfectly flexible, and at the same time unyielding lengthwise, any force, however small, by the steam, would compel the approach of the cast iron sides, however strongly propped apart, or breakage of some part must ensue;—such is the extreme of the theory. Practically, it is enough to say that by the force of moderate steam, the sheet iron top and bottom would each be distended into a figure approaching to a large sequent of a circle, and the cast iron sides proportionally drawn together.

This singular figure, in the aggregate of an oval form, having a flat place in each of its longer sides, would be held balanced and at rest by the contained steam—which diameter would my opponents take, in computing the parting force?

I shall not venture on the field of speculation here opened, lest an error in a collateral branch of the subject might unjustly taint the now important one at issue.

As to the fact of the upward and downward pressures on the sheet iron sides, being more effective than the lateral pressures on the cast iron sides, I shall limit myself to the repetition of a remark in my first communication, that they (the sheet iron sides) sustain the pressure "*in the disadvantageous manner of a string stretched horizontally bearing weight.*"

Is it more than fair that the ring and disk be now presented by me, as an exposition of the received theory, by which, as I have formerly said, "the horizontal action of the steam is alone considered," and showing its insufficiency to fulfil the actual conditions of the case. Before closing this article, let me put the following simple question: A weak place is in the boiler at top or bottom,—will a *vertical* tie near it, support, or relieve the weak place from a portion of the parting strain? if yea, what is the rationale? By the tenor of the latter part of Mr. L's. paper, I would fain hope that he is almost pursuaded to be a heretic. Were he so altogether, his loss of caste by the convertion, would endure but for a season.

Cincinnati, 27th June, 1843.

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## *On the Blowpipe.* By Theo. F. Moss, Mining Engineer.

(Continued from Vol. V, page 287.)

After examining a substance in a glass tube, and in a tube closed at one end, another portion of the substance must be heated, held in platina pincetts, before the flame of the blow-pipe, to see if it is fusible and to what degree; and for this purpose a scale recommended by Kobell may be used with advantage. This scale is, 1. grey Antimony ore, which melts in a common flame; 2. Natrolite, which melts in fine splinters in the inner flame, and in large pieces easily before the flame of the blow-pipe; 3. Adular does not melt in the flame of the lamp, but easily before the blow-pipe flame; 4. Almandine melts with difficulty before the blow-pipe flame; 5. Augite melts with more difficulty than almandine, but easier than 6. Bronzite, which can only be fused before the blowpipe on the edges of the finest splinters. It is advisable to have splinters of these minerals at hand for the sake of comparison, and the difference of fusibility of any mineral between any numbers of the scale is computed in decimal places, in the same manner as in determining the hardness. The relative fusibility of minerals, is of great use in determining the silicates from one another, which generally have the same chemical reactions before the blow-pipe, but have different degrees of fusibility. Care must be taken to use fine splinters of the mineral, as by using thick pieces, a mineral often seems infusible, when in reality it can be fused with ease; and with little practice the degree of fusibility of any mineral, as compared with the scale, can easily be determined.

Minerals heated in the platina pincetts often color the flame, in which case in order to determine correctly the color, a pure blue flame must be blown, and the mineral held at the edge of the flame, and thereby the presence of some substance may be determined with great certainty. An intense violet flame is produced by potassa; but if the same mineral contains soda or lithia, the flame will be colored either yellow from the soda, or red from the lithia. A green flame is produced by sulphate of barytes, the ores of telluriam, and some of the ores of copper. Many of the compounds of sulphur, arsenic, and antimony cause a pale, bluish-green flame. A beautiful blue is produced by the muriate of copper, muriate of lead, and seleniuret of lead.

After having heated a substance in the pincetts, it is laid on curcuma paper, and wet with a drop of water, and if the paper is colored brown, or brownish red, it shows an alkaline reaction, this alkaline reaction is shewn by all the combinations of the alkalies and alkaline earths, with carbonic acid, sulphuric acid, nitric acid, muriatic, and fluoric acid, and with water.

After having thus examined the substance, the mineral is to be examined on charcoal; if the substance is in powder, it must be made into a thick paste, and put on the coal. Most of the metals melt in the coal before the blow-pipe flame, and are oxidized, except gold and silver; platina, iridium, palladium, rhodium and osmium, are infusible.

Molybdinum, wolfram, nickel, and iron, are also infusible; their oxides can, however, be reduced by the inner flame. Most of the sulphates are fusible on coal, and are mostly changed to the oxides when sulphurous gas is disengaged. Most of the metallic oxides are infusible before the blow-pipe, but are generally more highly oxidized by the outer, or deoxidized by the inner flame. The following few oxides are fusible: the oxide of lead, bismuth, antimony and copper.

Salts soluble in water, melt before the blow-pipe flame on coal, but are mostly decomposed and leave their base on the coal. The alkaline salts are either drawn into the coal, or melt into a bead; most of the insoluble salts melt into a bead, which, on cooling, becomes crystalline.

Some substances on being heated on charcoal, undergo a change of color, by which they may be easily recognized; zinc oxide is white when cold, but becomes yellow when heated; and the original color of many substances when heated becomes much darker. A very important means of knowing minerals is their sublimate, that is, the volatile oxide which is deposited on the coal around the mineral when heated in the oxidizing flame. A white sublimate is formed by tin, zinc, antimony, arsenic and tellurium; the sublimate of tin is thick, and can be reduced by the inner flame; the zinc sublimate is, when warm, yellow, but on cooling, white, and burns with a white phosphorescent flame; if cadmium is present, the zinc sublimate is surrounded by a dark yellow sublimate of cadmium oxide; the sublimate of antimony is also thick, and volatilizes where it is touched by the blow-pipe flame; the sublimate of arsenic is white, in thin layers greyish, and far from the mineral, and can be volatilized by slightly heating; the sublimate of tellurium is white, but has a red or dark yellow edge, and vanishes on being blown on by the reducing flame, with a green appearance.

The sublimates of lead, bismuth, and cadmium are very similar; the sublimate of bismuth, is, when warm, dark orange yellow, when cold, lemon yellow, and in thin layers blueish, and can be driven from one place to another by the blow-pipe flame, when it is partly volatilized; the sublimate of lead, is, when warm, dark lemon yellow, cold, sulphur yellow, and in other respects like the sublimate of bismuth; the sublimate of cadmium is to be seen plainly only when it is cold, its color is yellowish brown, and in thin layers, yellow, and can be volatilized by any flame.

Silver melted on coal in the oxidizing flame, gives a slight dark red sublimate; when lead is present, the coal is at first covered with the sublimate of lead, and afterwards with the sublimate of silver.

After having examined the mineral before the blow-pipe without reagents, and no satisfactory results obtained, it must be examined with reagents, which must be chemically pure, otherwise false results will be obtained.

The reagents which are used, are:

Soda, and must, in particular, be free from sulphuric acid; borax, which must fuse into a transparent colorless glass; phosphate of soda, which must also fuse into a colorless glass; saltpetre, boracic acid, powdered fluor spar, a solution of nitrate of cobalt, which must not be very concentrated, and must be free from alkaline substances; tin, iron in the form of fine wire, lead, oxide of copper, litmus, and tumeric paper.

The relation of the mineral to borax or phosphate of soda, is to see its solubility, and the color which the discolored substances give to a bead of borax or phosphate of soda in the oxidizing or reducing flame. This reaction is of great importance for metallic compounds.

Most of the combinations of manganese give when melted with borax or phosphate of soda, a glass which in the oxydizing flame is violet red, but in the reducing flame becomes colorless.

All minerals containing cobalt give these fluxes a saphire blue color; chromium gives an emerald green glass with these fluxes.

The oxide of iron and most of the minerals containing iron, give these fluxes in the oxidizing flame, a dark red color, which, on cooling, becomes paler, then yellow, and when quite cold, is colorless; in the reducing flame the glass is bottle green, and remains so when cold.

The oxide of cerium gives in the oxidizing flame with borax, a red or dark yellow glass, which, on cooling, becomes paler; in the reducing flame the glass is colorless.

The oxide of nickel gives with borax in the oxidizing flame, when warm, a violet brown glass, which, on cooling, is red brown; in the reducing flame the color disappears, and the glass becomes greyish from small particles of reduced nickel; with phosphate of soda, the reaction is the same in the oxidizing and reducing flame, as with borax in the oxidizing flame.

The oxide of copper gives with borax and phosphate of soda in the oxidizing flame, a light blueish-green glass; in the reducing flame a brownish red, generally cloudy and opaque.

The oxide of uranium gives with borax in the oxidizing flame, a dark yellow glass, which in the reducing flame is a dirty green; with phosphate of soda, in the oxidizing flame, the glass is clear yellow, in the reducing flame a beautiful green, which becomes more apparent on cooling.

Molybdic acid gives with borax in the oxidizing flame, a colorless glass, which becomes brown in the reducing flame; with phosphate of soda, in the oxidizing flame, the glass is green, but, on cooling, becomes paler; in the reducing flame it is dark, but, on cooling, becomes a beautiful green.

Wolframic acid gives with borax, in the oxidizing flame, a colorless glass, which in the reducing flame is yellow, by a greater addition of wolfram, it becomes, after cooling, a blood red; with phosphate of soda, in the oxidizing flame, the reaction is the same as with borax; but in the reducing flame, the glass bead becomes of a beautiful blue color, when the acid is free from iron, but when iron is present, the glass is blood red.

Titanic acid with borax, gives with the oxidizing flame, a colorless glass, which in the reducing flame, becomes a dirty amethyst color; with phosphate of soda, with the addition of a little tin, in the reducing flame, the bead is of a blue violet color, but when iron is present, the color is red.

The other metallic oxides color the glass beads of borax and phosphate of soda, either not at all, or yellow; the earths also do not color the fluxes, but are all soluble in them except silica, which is not soluble in phosphate of soda.

In order to prove the presence of fluorine in a mineral, a small quantity of it is melted with phosphate of soda in the end of a glass tube, when hygrometric fluoric acid is formed, which destroys the glass.

To prove the presence of chlorine in a mineral, take a bead of phosphate of soda, charged with oxide of copper, so that the bead is strongly colored with the copper, then add the mineral, and if it contains chlorine, the flame will be of a beautiful blue. Bromine and iodine have the same reaction, but bromine colors the flame bluish green, and iodine pure green.

From the above it will be seen that no two oxides have the same reaction with borax and phosphate of soda, in both the oxidizing and reducing flame; therefore, it is necessary in all cases to examine the mineral with both fluxes.

### *On the reaction with Soda.*

When a substance is treated with soda, the two are generally melted together on coal, the substance is either applied in splinters or in powder, and the soda gradually added. A great many substances have the property of uniting with soda at a high temperature, and combinations are formed of which some are fusible, and some infusible. However but few belong to the fusible, viz., silica, and a few metallic oxides, viz., the wolframic, titanic, and molybdic, which, with the exception of the combinations of silica, are mostly drawn into the coal.

In order to try the fusibility of a substance with soda, if the substance is in the form of a powder, a paste is made with it and some soda; but if it is in splinters, it is covered with a paste of soda, and laid in a small hole in the charcoal, and at first slightly heated to drive off the water, and then strongly heated with the oxidizing flame; at first, when the soda begins to fuse, it is drawn into the coal, but makes its appearance again when it begins to unite with the substance, when it fuses with effervesence into a ball; but if the substance is insoluble in soda, but decomposed by it, it changes its appearance, and does not fuse into a ball.

If a substance is soluble in soda, and not enough soda has been added, a part of the substance remains undissolved, and is surrounded by a clear glass; but if too much soda has been added, the glass, on cooling, becomes opaque, therefore, it is advisable always to add the soda in small proportions, in order to see the changes which are produced by the addition of greater quantities.

A substance which is soluble in soda, if it contain sulphur or sulphuric acid, gives the glass a yellow red, or yellow brown color, according to the greater or less proportion of sulphur in the substance.

If a substance soluble in soda, is in the form of powder melted with soda on platina foil, and the fused mass has a bluish green color, it shows the presence of manganese.

If the mineral contains silica and the oxide of cobalt, the silicate of soda is formed, which will be colored blue by the oxide of cobalt.

By the reduction of metallic oxides by the aid of soda, the presence of metals in minerals, if contained in small quantities, can be detected with more accuracy than by analysis by the wet way.

If a metallic oxide is in combination with substances which render its reduction difficult, and the reduced metal difficult of determination, the mineral must be reduced to a fine powder and mixed with soda to a paste, and melted on coal before the reducing flame. The first of the soda is generally drawn quickly into the coal, therefore, it must be continually readded till no more of the assay remains on the surface of the coal. The first part of the soda serves to collect the metallic contents, and the latter to reduce the metallic oxides. After the reduction of the mineral, the part of the coal where the reduction took place, must be wet with a few drops of water, and all that part of the coal which is saturated with soda, cut out with a knife, and rubbed in an agate mortar with water to a fine powder, and slowly triturated that the coal and unreduced substances may separate easily from the more heavy metallic particles, and be easily drawn off with water from these. This must be continued till all but the metallic parts are removed from the mortar. If the mineral does not contain a reducible metal, the mortar will be empty, but if it contains only a small quantity of such a metal, there remains at the bottom of the mortar, shining flat spangles of the metal, if the metal was easily fusible and malleable; but a metallic powder if the metal was hard to be fused or not very malleable.

In this manner we may very plainly detect one-half per cent. of tin, and a still less proportion of copper in a mineral; if several metallic oxides are contained in the same mineral, they are generally reduced together to an alloy, sometimes separate reguli of each mineral are given.

The metals which in this manner may be reduced are molybdinum, antimony, wolfram, tellurium, copper, bismuth, tin, lead, zinc, nickel, cobalt, iron, silver and gold. Among these are some which are either totally, or in part, volatilized, and cover the coal with their oxides; to these belong antimony, tellurium, bismuth, lead and zinc: arsenic, cadmium and quicksilver are also reduced with soda, but are again immediately volatilized, and can only be obtained in a metallic form by sublimation with soda in glass tubes.

If, in reducing with soda, a metallic regulus is obtained, which is an alloy of several metals, it must be handled with borax or phosphate of soda, in the manner already described.

To be Continued.

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## *On the Ores used at Freiberg.—Translated from the German of C. A. Winkler.* By Theo. F. Moss, Mining Engineer.

At present between 180,000 and 190,000 cwt. of ore are used yearly at the works of Freiberg; of which from 60 to 70,000 cwt. are used in the amalgamation works, and the rest worked up in the furnaces.

With few exceptions all the ores are brought from the numerous mines of the Freiberg mining district, and are in a powdered form.

These ores are, in relation to their component parts, of great variety. The quantity of silver in a cwt. of ore, varies from 0 to many 100 ounces in the cwt., and some of them are of the richest description of silver ores, but the average amount is between 2 and 3 ounces to the cwt.

Some of the ores are more or less rich in lead, but the quantity of lead ores which contain more than 30 per cent., is hardly $\frac{9}{100}$ of the whole mass of ore; copper ores which contain several pounds of copper in the cwt. are but few; but traces of copper are found in most of the ores, therefore the silver from the amalgamation process always contains some copper, although the copper ores are never at Freiberg, used in the amalgamation works. About 14 to 18 per cent. of the whole quantity of ore is either poor in silver, or totally free of it, and is iron pyrites, used in the first smelting process.

The other component parts of the Freiberg ores are very various, as is to be expected from the various and numerous veins from which the ores are brought. The ordinary mixtures are quartz, hornstone jasper, heavy spar, and calcareous spar; fluor spar, on the other hand, is at present but seldom met with. Iron pyrites is common, but is not at hand in sufficient quantities to supply the necessary addition for the first smelting; some of the ores contain a great deal of zinc, antimony or arsenic, and iron ochre and carbonate of iron are found in greater or less quantities.

The Freiberg ores belong, on the whole, to that class of ores which are with difficulty smelted, and the most infusible kinds are those which are composed in most part of quartz or heavy spar.

It is worthy of mention that some gold is found in most of the Freiberg ores, and appears to be contained in the pyrites. The per centage of gold is, however, so trifling, that it would not cover the cost of separation. A small profit would accrue from separating the gold from the silver obtained by the smelting process from some varieties of the pyrites, were it not found more profitable to use these ores in the amalgamation, when most of the gold is lost in the reviving process *(anquickprozess)* without being concentrated in the silver amalgam.

The ores used in the amalgamating works must neither contain lead nor copper. Lead would make the amalgam impure, and the lead would be lost in the residuum; copper ores by the Freiberg amalgamation process would cause the silver to contain too much copper, and much of the copper would also be lost in the residuum.

Therefore, the ores which are used for the amalgamation *(verquickung)* contain as little lead and copper as possible, and from 3 to 4 ounces silver to the cwt. of ore, but at the same time sufficient pyrites for the decomposition of the salt used.

All other description of ores, whatever may be the proportion of silver, lead, copper or pyrites, are given over to be smelted at the furnaces.

## *Experiments and Observations on Möser's Discovery, proving the Effect is neither due to Light nor Heat.* By Horatio Prater.

(Continued from Page 72.)

6. *As regards Impressions on Glass.*—We have already observed that heat does not seem to increase the effect of *metal* coins on glass. Neither did *long contact;* for a fourpenny piece, left a *week* on a piece of looking-glass, only left the usual spectrum, no *figure* being visible. The same remark applies to large *printed* letters. At least, some paper with these, after remaining pressed two or three days without giving any impression, was then heated for five hours, so pressed, at about 160°, but no impression was made. On another occasion, print and writing were left a week on a glass mirror without leaving an impression. When, however, thinner paper and larger letters were used, and heat and pressure applied as above for four or five hours, these letters were plainly visible; but, as appeared to me, far more easily erased than were the spectra of coins on copper plates.* A

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* On a copper plate also this *thin paper* (not being well dried first) gave a permanent and very visible spectrum, the lettering being clearer than on glass: not due to oxidation, *i. e.*

slight touch of the finger, for instance, erased the letters in question. They were produced in this case in consequence, no doubt, of the thinner paper being *moister* than that first used.

Heat does not appear to increase the effect on glass. A fourpenny piece under a shilling for three hours, at 160°, left no spectrum.

On putting a penny on a sovereign, and leaving them for three hours and a half at the above heat, I thought the spectrum of the penny slightly visible; but as the image is never so apparent as on polished metal, I shall not venture a decided opinion on this point as regards glass.

A *polished*, *boiled*, and then well dried half-crown, gave as good a spectrum on a glass plate in twenty-four hours, as did a dirty half-crown; but I thought the spectrum of the former disappeared sooner by breathing. On a far thinner glass plate, a bright, boiled fourpenny piece, left the same time, gave no spectrum at all.

7. *Polished surfaces not appearing capable of receiving the impressions.*—These exceptions from the general rule I have found to be talc, and among the metals tried, steel to a certain extent, platinum and gold.

Whether heated or not with the coins on it, I have found *no* spectrum produced on talc, except in one instance, where a tarnished half-sovereign had been pressed some days by a half pound; and even here the mere margin of the coin was *barely* perceptible.*

On steel, after remaining twenty-four hours, I found a *very* slight evanescent spectrum produced by a small piece of brass, and on *one* occasion by a half-sovereign very much tarnished; but as heat did not appear to increase or hasten the effect, we may consider steel almost unsusceptible. The spectra just named disappeared entirely after breathing *twice;* and no *permanent* spectrum was produced, though the piece of brass above mentioned was placed even on the top bar of a grate, and, of course, kept very hot, for two or three hours.

Under the head "Thinness of the plates," experiments, showing the incapability of platinum to receive images are mentioned.

The same remark applies also to gold. I kept a shilling and a farthing on two different occasions, for twenty-four hours or longer, on a well polished plate of gold, yet they *barely* left a marginal spectrum; and this spectrum, as in the case of steel, disappeared *entirely* on breathing on it twice. As the gold used was not free from the usual alloy of copper, possibly this was the cause of its receiving even the very slight spectrum it did. However this be, these experiments seem almost sufficient to establish the important general principle, viz., *that the less metals are oxidable by exposure to the air, the less is their susceptibility to receive spectra.*

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oxidation in the usual sense of the term; but, on rubbing it off, the surface of the copper was left polished; there, no doubt, was some *very slight* chemical action, as large printed letters on perfectly well dried paper were not taken off on a copper plate, the heat at 160° being applied for five hours; or on another occasion, the print remaining a week on the plate, and pressure being used.

* Talc, like platinum, is not easily acted on by acid.

8. *As regards comparative polish in metals.*—1. A new sovereign, a new half-crown, and a new farthing (all well polished) were kept on a bright copper plate, at 160° or above, on *two* successive occasions, for four or five hours. The gold and silver left only *very* slight permanent traces of their margin, the copper left none at all; but its spectrum, when the plate was breathed on, became, I thought, even rather more evident than the spectra of the gold and silver, these being likewise breathed on. 2. A *tarnished* sovereign and a *tarnished* half-crown being laid on the same copper plate, and kept at the same heat *only three quarters of an hour,* a permanent and *far more apparent* spectrum was produced, than in the former case; the *whole area* where the half-crown had laid, was covered with a whitish cloud, and the impression dimly sketched. 3. By selecting a halfpenny *very much* tarnished, and letting it remain five hours on a bright copper plate, heated to 160° or so, and subsequently for thirty-six hours in the cool, a *permanent* spectrum was produced, in which all the *lettering* of the coin was *beautifully* visible; yet here was copper on copper. But as I found this impression to go off completely at a heat far below what the impression did, at experiment 5, below, the general principle, that silver gives a *stronger impression,* remains. 4. A *well polished* new sovereign and a *tarnished* sixpence being laid on a bright silver plate for four hours, and kept at 160°, the sovereign had left no spectrum, but the sixpence had left a *permanent* one, in which almost all the lettering appeared, so plainly was it visible. 5. A *perfectly* polished half-crown was laid on a pretty well polished sixpence, and a *purposely* tarnished one on a purposely tarnished sixpence, and put on the same plate with the half-penny (exp. 3, above), heated five hours and left thirty-six hours afterwards. The lettering, &c. of each sixpence was visible, but *far* more of the most tarnished; and also this was the case with that of the most tarnished half-crown, as regarded its spectrum. That of the polished was scarcely visible. But the lettering of neither half-crown was visible, though they had remained so long and been heated. This experiment also shows how much the effect is strengthened by *actual contact.* A similar experiment was made in the closed deal box (mentioned in Section 5). The copper plate was laid upon a *polished* and boiled fourpenny piece, and this on a half-crown similarly prepared; after ninety-six hours, no spectrum whatever of the half-crown was visible, by breathing or otherwise, but the fourpenny piece, in actual contact, had left the usual spectrum. The plate had remained *perfectly* polished. All these experiments show that the dissimilarity of metals is not of such importance as has been conceived: they show the difference wanted to produce the effect is a difference in brightness or oxidation, *i. e.* as far as a *permanent* and good impression, *showing the lettering, &c.* is concerned; for I find when left on the plate half an hour or so, tarnished or polished metals give equally good spectra. But in this case the spectrum is only made apparent by breathing, and of course shows *nothing* of the lettering, &c. However, even in this case, the spectrum of the tarnished sovereign disappeared less soon by breathing on it than did that of

the polished one; so in reality the spectrum of the former may be said to have been the most perfect.

The same remark applies to a glass plate (see Section 6, as regards glass, &c.)

9. *Which metal receives images fastest, copper or silver?*—My experiments lead me to say copper, whether heat be applied or not. When the same degree of heat was applied, I found a sovereign produced a good *permanent* spectrum (impression) on a bright copper plate, although only an evanescent one (one seen only when the plate is breathed on) was produced on an equally well polished silver plate, placed at the same time at the same heat. When heat was not applied I found the copper received an *evanescent* spectrum first.

10. *As regards the effect of interposed substances.*—As every substance tried left a spectrum, I did not much expect that the influence would permeate any lamina, even of the thinnest description. Accordingly, when a sovereign or shilling was left twenty-four or forty-eight hours on a piece of stiff, though very thin, paper, it gave no spectrum, but the mark of the paper was alone visible. The experiment was repeated, half the coin resting on the copper plate, and half on the paper: and although it remained a fortnight in this position, the half only *in contact* with the plate was visible by breathing on the paper, leaving *its own* spectral image just as if no coin had rested on it at all.

The same experiment was repeated with the thinnest possible layers of talc, gum, cork, and whalebone, glass, plane and concave,* with the same result. Each substance left its spectrum, the part where the coin rested on such layer not being at all distinguishable. The spectral image of the square piece of talc was perfect to the minutest outline, and left its straight mark under the sixpence equally well as at other points. These experiments render it clear, that the effect is not due to latent light, for otherwise how could it happen that a coin does not leave a spectral image when left on *transparent* substances, glass, or talc, *even a fortnight?* They also show it does not depend on heat (at least alone), for a heat of 160° soon passed through thin glass and talc, and I found it impossible to keep my finger on glass or talc so placed. Yet we have seen above that even gold left two hours on talc so heated left no spectrum, permanent or temporary. So great is the effect of interposed substances, that even a *slight tarnish* on the metal exerts a very obvious effect.† One shilling was left twenty-four hours on a polished part of the plate, and another on a part of the same slightly tarnished (but yet sufficiently bright to see oneself perfectly). A very slight image only was left in the latter case, that entirely disappeared when breathed on twice, while that on the polished part of the plate remained, after being breathed on twelve or fourteen times.

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* With the glass the experiment was only continued forty-eight hours; with the paper, talc, and cork, a fortnight, silver coin being used; with the whalebone and gum, ten days, gold coin being used.

† One spectrum, however, may be made on another; thus, after talc had remained eight hours on heated copper plate, and left a permanent spectrum, a sovereign put on this an hour left a permanent spectrum.

A sovereign left twenty-four hours or above, tarnished, gave scarcely a perceptible spectrum, and a sixpence, none at all. On such a surface, a sovereign was left on two different occasions, under a penny, for three hours, at a heat of 160°, and barely left a permanent spectrum of its *outer* margin; while on a well polished surface, at same heat, the outline of the impression also would have been left as a permanent spectrum in an hour or two.

11. *Mass.*—Mr. Hunt considers, that mass exercises an influence, and increases the effect. In my experiments, however, I could not detect this. A farthing on a copper plate gave as good a spectrum as a penny, and when heated to 160°, the farthing gave far the best, though the penny had a halfpenny laid on it. A fourpenny piece, too, gave as good a spectrum as a half-crown, pressed by another above it, in the same time, the contact being equally good in each case. *The contact in these cases was made as equal as possible with the copper plate.*

12. *Does the thinness of the plate exert an influence?*—A farthing (in two experiments) pressed by twelve or fourteen pounds weight, on a polished piece of platinum foil, in thirty hours, left no spectrum at all; neither did it on a fourpenny piece, or a sovereign, or half-sovereign, when kept three or four hours at 160° under the same weight. I found a spectrum could be made on nearly equally thin zinc plates, (zinc *foil)* by leaving a sixpence on it an hour or two. Zinc not being elastic, allows the pressure to be equal. The particular chemical nature of platinum has, however, much to do with this effect; for I found that when a fourpenny piece, or another small brass metal object, was left on a highly polished lamina of steel—heated to 160° or not—a spectrum was scarcely made. That elasticity and consequent *imperfect contact*, is not the sole cause of the incapacity of thin lamina of platinum and steel, for receiving spectral images, was to me rendered *probable* by observing that coins, placed on a thick copper plate, seldom were in *perfectly* close contact, yet gave good spectra. In order to come to a more definite conclusion on this point, I got a lamina of bright copper, even thinner, and as elastic as the platinum lamina, above mentioned. Gold or silver coins left twenty-four hours on this, gave a spectrum scarcely visible; but on leaving a half-sovereign for two or three hours on it, exposed to heat of 160°, as above, and pressed down by exactly the same weight, the half-sovereign left a *permanent* spectrum very well marked indeed.

The result of this experiment obviously shows, that although thinness and elasticity may have some little effect, the principal cause for the formation of the spectrum is the peculiar *chemical nature* of the metal, and *that a spectrum cannot be produced on a non-oxidable metal, such as platinum.* Bright silver and copper plates are well known to *tarnish* by exposure to the atmosphere, (the former, perhaps, rather by forming a sulphuret, than an oxide,) but no matter how. I have also found that spectra could be formed on tin and zinc plates, both of which, of course, are oxidable. So on copper coated with mercury, the mercury in such case, no doubt, readily tarnishing: (see Sec. 7. Polished surfaces not receiving spectra). Having decided that the effect in question is due neither to light nor heat, to what cause, it may be asked, is it to be ascribed?

*Conclusions.*—1stly. As *brightness* of the plate is indispensable, and with brightness must exist an *increased tendency* to tarnish, or enter into chemical combination. 2ndly. As the plate must be of an oxidable metal, and judging from the experiments with silver and copper, the more oxidable the better. 3rdly. As the more perfectly the coins are cleaned and dried,* the less the effect, and as a dry perspiration (so to call it) must exist in a greater or less degree on all coins, since they pass through so many hands, and as perspiration is slightly acid. 4thly. As even with *clean* coins the effect† by *actual contact* must be admitted, but still is greater when there is a difference in the nature‡ of the metal; and 5thly. As when the metals are not in contact (being removed only the one-twentieth of an inch apart), no action or spectrum is evident, if the free circulation of air, and the connexion with dust be prevented—taking all these and minor considerations into account, we come to the conclusion that the effect in question is dependent on *chemico-mechanical* action, or what Berzelius has called *catalytic* action. No doubt it may be urged against this view, that the action takes place when the coins and plate are both heated, and hence quite dry. But this is no solid objection, for the adage "Corpora non agunt nisi sint soluta," is not true, as hundreds of examples in chemistry show. The very fact of heat itself increasing the effect, is all in favor of a chemico-mechanical view; for heat increases the tendency of copper to oxygenation, and tends also to volatilize any feeble acid matter on the coins. But again, if it be said the spectrum rubs off, even *when permanent and clearly defined* (as we have shown), *and leaves a polished surface under it,*—this we admit; but still this surface has suffered an *almost imperceptible degree* of oxygenation; for so slowly does this effect take place, that it is only visible when much advanced, as will be evident to any person who watches the gradual tarnishing of copper plates. Möser's discovery shows that *very slight* chemical action is often going on, *which has been previously overlooked.*

The chief difficulty that occurs to the above view, is that the effect takes place, to a slight extent, on glass; but in all my numerous experiments I have found that the effect is much *less* on glass, than on well polished copper; for in no case has a *permanent* spectrum been made on glass, even by the longest contact.‖ It will also be remembered that I found no effect whatever produced on talc. Now, the talc scratches easily, glass, of course, does not; but talc is probably less soluble in acids than glass; at least in my trials it did not seem at all acted on either by nitric, muriatic, or sulphuric. To be sure, you *perceive* no effect of these on glass, but it does not seem impossible but that some *very* slight effect takes place, and that the alkali of the glass is *very* feebly acted on, as glass is a *compound* body. *Contact*, at all events, may be presumed to have an influence on the affinities of one of its elements, whether there be even the *slightest* degree of decomposition or not. Now, this influence is the catalytic influence; for it has been shown above, that without actual contact, *and when all dust is kept off*, neither silver nor copper, even at the one-twentieth of an inch from the glass plate, produces any effect, though kept there ninety-six hours. (See Sec. 4, of heat generally, end.) In consequence of this slight alteration in affinity, the parts of glass which have been in contact some time with coins or other substances, condense the breath differently from those parts which have not: hence the spectrum.

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* Moisture much increases the effect. Thus, when one surface of a shilling was rubbed over with ink, and such surface put on the copper plate, and heated to 150°, a mark *much* more difficult to be effaced was left than when this degree of heat was applied without moisture.

† This is equally true, as will be remembered, with regard to glass plates.

‡ The *general* result of all the above experiments show this; and, of course, an alteration of affinity from contact, is far more probable when metals are different than when the same: though if one be dirty, this makes it approach the nature of a different metal.

‖ A permanent spectrum has been proved (see experiments) to be but a higher degree of an evanescent one.

The effect of glass, *supposing it not susceptible of a gradual change by the action of air similar to oxidation*, is rather in favor of the spectrum depending on a mechanical than a chemical action. I have, in consequence, ascribed the effect to a mechanico-chemical action, or a *catalytic* action, meaning thereby an action so slightly chemical, as, in the present state of the science, to be scarcely appreciable.* The attraction of glass and oxidable metallic plates for *dust*, &c., is very great; and is, perhaps, dependent on the same cause as their attraction for oxygen. Whether or not, I feel pretty well convinced, after a laborious investigation of the discovery in question, that it is not of that wonderful character that Möser and others have supposed; nor calculated to alter our ideas of vision, or of the nature of light. On the contrary, I think with Fizeau (a short notice only of whose memoir I have seen), that no effect *of any consequence* is produced *where organic matters are carefully removed by boiling water and polishing;* for such is perhaps the philosopher's opinion just named, and in as far as our opinions agree, he has the priority. Begun by a purely catalytic action, it is only continued and developed in any *marvellous* degree, when those circumstances are present that permit it to assume a more strictly chemical character.

Lond. Athenæum.

## *Iron-Founding.—From the Glasgow Pract. Mech. & Eng. Mag.*

(Continued from Page 62.)

*Process of Moulding in Green Sand.*—Take, for example, the front of a register grate, which is a familiar instance of light flat moulding. Its construction is that of two jambs joined at the top by a cross piece. On the back, or inner surface, it is quite flat, and is ordinarily ornamented on the face with raised figures of flowers, &c. A box is selected that will receive the pattern, and have a few inches to spare, that the pattern may be completely surrounded with sand.

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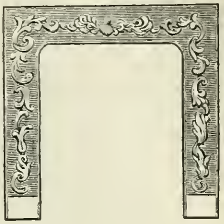
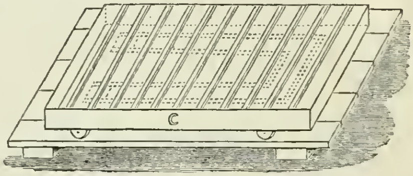
* In coming to this conclusion, I have not forgotten another difficulty, viz., why a well *polished* and boiled copper coin produces a spectrum on copper plate. The effect, even when continued an hour or two at a heat of 160°, is *very* slight, and I found it to disappear entirely by twice breathing on the plate. *Contact* then, of the same metal SLIGHTLY modifies chemical properties; such, on the present view, is the inference to be drawn from this fact.

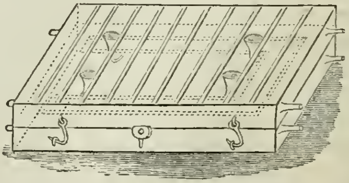
The pattern is then laid down either on the surface of a bed of sand, prepared in the upper box, which is lying inverted on the ground, or on a flat board of sufficient size to support it at all parts. In either case the pattern is laid down on its back; there is next thrown over this a layer of fine sand of an inch deep, constituting the facing of the moulding. It is passed through a sieve to detain the coarser parts. Then, upon the board or upper box, which we shall call A, the drag-box, B, is placed in its proper position in respect to the pattern. The annexed figure shows how things now stand.





It is necessary to spread the facing of sand before laying down the box, as its ribs prevent the equal distribution of the sand over the pattern. Then a larger quantity of sand is passed through a riddle which saves the small stones and other refuse in the sand. An additional quantity of the common sand is thrown in by a shovel, and the whole is now rammed down by the flat rammer as equally as possible. This is facilitated by a considerable depth of sand having been laid on, as inequalities in the force of ramming are diminished at the surface of the pattern. The box is again filled up with sand and rammed all over with the round-faced instrument. When the sand is properly set, and squared flush at the surface with the box, B, the whole is turned over, (avoiding sudden shocks of any kind, which tend to loosen the sand) and well bedded on the ground with the box B undermost. The box A, or the board, as it may happen to be used, is lifted off, and the temporary bed of sand in the box A is destroyed. The upper surfaces of the sand in the box B, and of the pattern imbedded in it, are cleaned and smoothed by the trowel, so that the surface of the sand is made flush with that of the pattern all round, and also meets the edges of the box. This forms the *parting*, or place of separation of the sand in the two boxes; and that they may afterwards separate properly, dry sea sand is sprinkled over the parting surface, and has the effect of preventing the adhesion of the sand to what is afterwards superimposed, by entering and drying its pores. The box A is now laid on the other, guided by the pins, and both are fastened together by the hooks. In bringing them together their meeting surfaces ought to be cleared of sand so as to make them bear freely and steadily. Preparations are now made for the construction of the *gates*, or passages, for the iron from the external surface into the mould. In the moulding of a register-grate front there are usually four gates constructed, into which the iron is poured simultaneously. The necessity for having so many openings for the iron must be obvious, on considering that iron rapidly solidifies as it cools from a melting temperature, and, of course, *sets* in the form of the place it occupies.

To provide for the gates to the moulding, four taper pins of wood are struck in the sand of the lower box at a short distance from the pattern, projecting upward between the ribs of the upper box. Sand is, as before, thrown into this box, covering the flat side of the pattern, and is rammed between the ribs until the box is filled flush with itself. The pins are now withdrawn, and the holes formed by them are widened at the top into bell-mouths to receive the iron the more readily, and are well smoothed there to prevent the metal from carrying in with it any loose sand. The upper box is now taken off with care, to preserve the impression of the upper side of the pattern; and the edges of the moulding in the box B, in contact with the pattern, are wetted with a swab to make the sand, at these corners, the firmer, and to prevent crumbling on withdrawing the pattern. Still farther to facilitate this, as the pattern fits closely in its bed, it must be loosened before being drawn, which is simply effected by taking hold of the pattern by a sharp point, if of wood, or by studs, which are riveted into it when of iron, and gently tapping them laterally and downwards. The pattern is next drawn slowly out of the sand, and it often occurs that the moulding is broken at one or two places, in spite of these precautions, and especially if there be much carved or ornamental work on the pattern. The moulder has, therefore, in the first place, to repair the damages by adjusting disjointed parts, and making up fractures by the addition of sand. All the more prominent and most exposed parts of the moulding, as the extremities of the ornaments, are treated with a touch of the swab, which must be lightly applied so as not to spoil their sharpness. This process, indeed, with that of applying the blackening, now to be described, are the most difficult parts of the art of the flat-moulder. The blackening has now to be applied, and it must, by some means, be pressed down upon the mould at every part, and made to adhere to its surface. To effect this, pease-meal is used—it is first dusted thinly over the surface of the mould. It rapidly absorbs the damp of the surface sand, and is converted into a pasty matter. The blackening is next dusted over the newly formed paste, and over all, the pattern is placed in its position and pressed down. Thus the blackening is made as smooth as the pattern, and is at the same time well held down to the sand. Channels are now scooped out of the surface of the sand, joining the gate-holes to the moulding; and if the pattern be thin, each channel is widened as it joins the mould to afford a sufficient inlet for the iron. They are slightly swabbed round the mouth to confirm the edges against the abrasive action of the iron.



Having finished the moulding, and got it in order for the reception of the iron, the upper box is finally put on the under one in its place, and fastened down upon it.

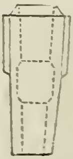
All is now ready for the pouring of the iron. In the adjoining figure of the boxes in this condition, the moulding is represented within, and the gates leading to it from the surface.

There are several points in the practice of green-sand moulding generally, to which great attention must be paid. In the preceding account, we alluded to the necessity of the sand being rammed as uniformly as possible. Now, it may be too closely rammed altogether, so as to impair its capability of conducting away the confined air, and the gases generated by the heat. There must be a degree of ramming applied proportioned to the heaviness of the casting. If the sand be too closely rammed, the current of iron flowing over the moulding, is agitated by the air not being allowed to pass freely off. In consequence it breaks up the sand and heaves it to the surface, and it is easy to see that this produces excrescences on one side of the casting, while corresponding deficiencies exist, from the same cause, on the other side. If, again, the sand be too loosely rammed, the iron by its weight presses it outward off the moulding, which renders the surface uneven, and swells the casting. Moreover, a certain degree of humidity in the sand is necessary for the goodness of the casting. When the sand is deficient in moisture, the iron is apt to penetrate its pores on the under surface, and so detach the particles of sand there, producing an effect similar to that occassioned by over ramming. On the contrary, if there be an excess of dampness in the sand, the iron, by the sudden formation of aqueous vapor, is frequently repelled altogether, and ejected at the gate like shot. Should this not take place, though the iron may make its way through the mould, the bubbles of vapor form cavities in the casting towards the under side principally, as this side bears all the *run* of the iron passing over it, and is thus more severely tried than the upper side, the iron simply rising to that side, and is there at rest. Excess of dampness, and of over-ramming, are thus nearly alike in their effects, and are the more dangerous extremes. In cases of very large castings, if the air, expanded by the heat, and the other gases generated, do not find a ready vent, they burst through every resistance with explosive energy.

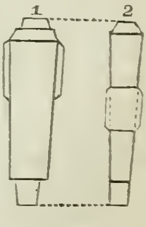
The quantity of blackening to be applied must also be a particular quantity. In noticing, in a former part of this paper, the nature of blackening, and the manner in which it is operated upon by the iron, reference was made to the continued evolution of gas by combustion. If then, by the action of the iron upon the blackening in the mould, too much gas be formed, it collects in globules, and forms corresponding indents in the casting. The skill of the green-sand moulder consists in so laying on the blackening as to produce equilibrium between the antagonistic forces of the iron advancing, and the resistance of the gas produced. After having been pressed down by the pattern, the loose blackening left is rubbed off and blown away. When this is not attended to, the blackening is raised in layers from the surface by the iron, and deposited in other positions, giving the casting, when cool, a rough, clouded appearance. In forming the surface of the blackening upon ornamental moulding, by pressing down the pattern upon it, care must be taken that the pattern be perfectly dried before being laid over the blackening; for if at all damp, this will adhere to it, and take the pease-meal with it, and so destroy the moulding. And even though it be quite dry at first, yet it may, by lying too long in the sand, contract damp, and so spoil the mould. Swabbing is avoided when not essentially necessary, as the formation of vapor, by the contact of the iron with the water, is, as before noticed, apt to agitate the current, and make the flow irregular. The object of forming the gate to one side of the moulding, is to check the violence of the iron in motion, and to introduce it with regularity. Were the gate formed directly over the moulding, any delicate ornamental work below would be worn off by the continued action of the iron, though certainly it may be so placed, if the moulding at that part be plain. We noticed the necessity of a number of gates to the moulding. The number of these varies with the extent of the surface of mouldings in general, and also according to their thickness. A comparatively deep moulding might be well filled by only one gate, while another of just the same horizontal surface, but shallower, would require two or more gates. In short, there must be as many gates as are requisite to ensure the metal's having thoroughly filled the mould while it is yet liquid. The iron, should, therefore, be run in as quickly as possible to fill the mould completely, and this is especially to be attended to in cases of light-flat, and hollow moulding, as in these the extent of cooling surface is great, compared with the depth or thickness of the iron.*

Before dismissing the subject of light-flat moulding, one other elegant example may be described, introducing the use of three boxes for a moulding. The instance referred to is the moulding of the cast iron bushes, which are fixed in the naves of the wheels of wagons and other vehicles, to sustain the wear of the axle.

The annexed figure is a sketch of an ordinary bush for cart wheels. The dotted lines show the form of the interior, which is a tapered hole. At the middle of the length, as shown, a chamber is formed in the bush, so as to surround the axle —its object is to contain the grease for lubrication. These bushes are always cast in pairs, and the cores for them are cast iron pins, having the form of the axles for which they are intended. These pins, which serve for many successive castings, are turned and polished in the lathe, for the purpose of communicating a smooth surface to the interior of the bushes, by which the expense is avoided of boring them out which would be necessary, were sand cores employed.



The pattern of the bush is solid, and has, in addition, a core print on each end to steady the core. This is shown by fig. 1, annexed. Fig. 2, shows the core extended at the ends in correspondence with the prints. Round the middle of its length a



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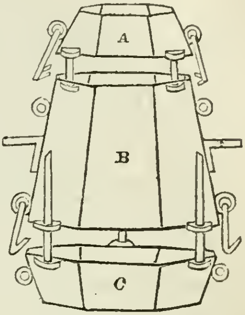
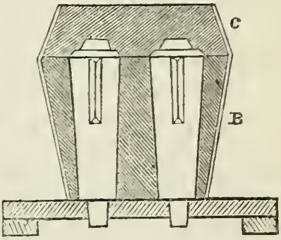
* Mr. Neill's patent tiles for roofs afford a remarkable example of the extreme thinness of casting practicable. These tiles are each 18 inches by 6 inches, and weigh 28 lbs. per square yard, which gives one twenty-fourth of an inch for their thickness. Small as they are, they require two gates, on account of their extreme thinness.

thickness of sand is rapped to form the grease-chamber in the bush. This part is made of sand, so as to be separable, and thus allow the core-pin to be driven out of the bush when cast.

The box in which the bushes are cast consists, as already mentioned, of three parts. The length of the middle part is made the same as that of the bushes between the small end and the tops of the feathers. The parts are octagonal in plan, as represented in the annexed figure. A the top, B the middle, C the bottom.

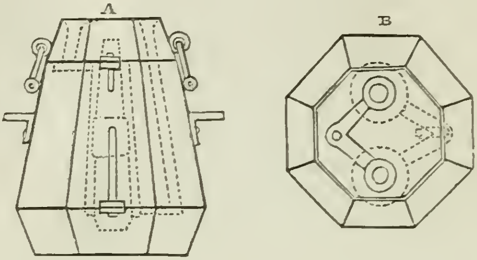


In proceeding to mould the pattern, a flat board is laid down level, with two holes in it at a suitable distance from each other. Upon this board a pair of bush-patterns are set down on their small ends, the points passing through the holes in the board, to keep the pattern steady. The box B, is inverted and laid down over them, and filled with sand, which is rammed about the patterns level with the tops of the feathers on them. The box C, is now fixed on and rammed with sand. The figure annexed is a sectional view of the boxes and their contents at this stage of the process.



The two boxes together are inverted and set down—the box A, is fixed on the uncovered end of B, and it likewise is rammed flush with sand. Two holes are next pierced downwards in the sand, with the handle of the rammer, one to each side of the patterns. One of them extends just through the box A, the other reaches down to the box C. A and B, together, are lifted off C, and turned over, the patterns, loosened by tapping, are next drawn out. A and B are then separated. Two prepared core-pins are next set, as vertically as possible, into the recesses left by the prints in the sand of the lowest box; on the surface of the sand at each end of the box B, channels are cut joining the gate-holes, made by the rammer, to the two mouldings, in such a manner as that the short gate will be connected with the upper end, and the long gate with the under end of the mouldings. B is lowered over the cores, and fixed to C, being directed by the long guide pins at the side. A is next replaced, guided also by pins, and fixed to B. It must be placed with care, as the upper ends of the cores are at the same time entering the recesses made by the prints. And thus the cores are secured between the boxes A and C.

The moulding, as thus finished, is shown in fig. A, which is an external view of the whole, with the interior arrangement in dotted lines. Fig. B, is a view of the upper and under ends of the middle box, showing the gate channels. The iron is poured into the long gate, falling against the bottom of it, the force of the iron is broken, and it runs gently into the mouldings, rising within them till they are filled, when it passes into the short-flow gate, as it is termed; from which it issues, carrying off the refuse it may have gathered in its passage. Blackening is not applied to these moulds, as their roughness is of no consequence.

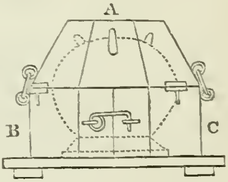


Section II.—Having in the first paper on this peculiar art, given two detailed examples of the mode of moulding and casting light, flat ware, illustrating, generally, the manner of conducting the manufacture of these goods; the practice of hollow moulding falls now to be described, as that branch of moulding naturally precedes in order of description, the heavier species of green-sand moulding.

The distinct objects of hollow moulding are comparatively few in number, and small in dimension; there are moulding boxes for them individually of corresponding shape, generally manageable by one person. Boxes in two, three, or four parts, are employed as the necessities of the case may require. We shall select, for example, the moulding of an Irish pot, of which the annexed is a sketch. The body of it is nearly spherical, drawn in at the neck, and opening towards the brim. It has two ears at the neck, by which it is moved about when in use, and three feet on the bottom. The pattern is an exact model of the pot, being in two halves separating vertically. The patterns of the feet and ears are also loose on the body of the pattern, fitting to it by pins. To form an original pattern, the method usually adopted is that of moulding in loam, which will be understood afterwards, when we come to describe this branch of the art. In the mean time, it is sufficient to state, that the rough cast pattern is chucked in the turning lathe, and turned within and without to the required form and thickness, in doing which, it is facilitated by boring four longitudinal rows of small holes through the pattern at equal distances round it, by which its thickness at any part may always be ascertained. Having been smoothed and polished, the pattern is taken from the chuck, and cut in two equal parts, in which holes are bored at the proper positions for receiving the pins of the ears and feet.

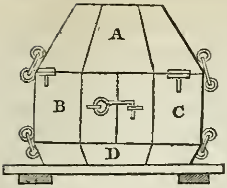
The pattern is moulded in a box, consisting of four parts, named the top, marked A in the ensuing figures, the two cheeks, B, C, and the bottom, D; the division into parts is similar to that of the moulding box for axle bushes described in the preceding paper, supposing the middle part divided vertically in two, corresponding with the cheeks, B, C. The pattern being moulded in an inverted position, the top, A, is made to inclose the bottom of the pot, as far up as its largest diameter; the cheeks, B and C, inclose the remaining portion of the pot, and the bottom, D, serves to close up the mouth of it.

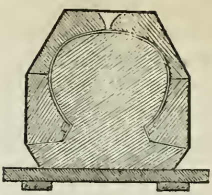
The two cheeks are first of all laid down on a level board and linked together; the pattern is then laid down on its brim within the cheeks, being raised off the board by a slip of wood, of which the thickness is adapted to bring the largest diameter of the pot to the level of the upper edges of the cheeks. The patterns of the ears are attached, and sand is rammed in round the pattern flush with the cheeks, making the parting surface on the centre of the pot. The surface having been sprinkled with parting sand, the top, A, is put on, led into its place by guide pins, and fastened to the cheeks. Sand is again rammed into the level of the mouth of the box, the patterns of the feet and the gate pin being set in their places in the course of the ramming of the sand. The annexed fig. shows the position of things as now described. The whole is next inverted, and the board and slip of wood removed. The surface of the sand round the brim of the pattern is smoothly sloped off to the edge of the box, forming the parting surface, and the bottom, D, is fixed on. It is also filled with sand. The body, or core, of sand filling the interior of the pattern, is pierced in several places with a pricker sent down to the pattern, forming thereby channels of escape for the air expelled by the metal introduced. The whole is finally re-inverted, D lying undermost, and placed on a flat board with a hole in it to allow the escape of the air. The sand outside the pattern is sometimes pricked, though this is but of little importance.



The part A is now separated and lifted off, carrying the feet and the pin with it. The cheeks, B, C, are next separated horizontally, taking the ears with them; and the half patterns are withdrawn from the core. The external and internal moulds, thus exposed, are sleeked up with appropriate tools, and blackening is dusted on them, and also sleeked up. The patterns of the feet and ears, and the gate pin are drawn out, the boxes, B, C, are replaced exactly as before, and the box A, above them, the whole being again bound together. The mouth of the gate is next formed and smoothed. The space occupied by the pattern is now vacant for the metal. This is an external view and section of the box and moulding. In the section are shown the parting surfaces, and the slope of the under one.

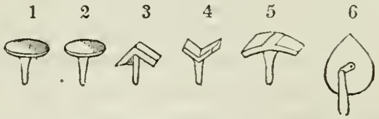
All dished utensils are cast with their mouths downwards, and in some cases, the area of the mouth is so small, compared with the





largest diameter, as to render it necessary to bind down the core in the mouldings; for it is very evident that the iron lying so far in below the core, tends, by its upward pressure, to lift the core off from its base. Such a result would, of course, spoil the casting. This binding is requisite in kettle mouldings in particular. It is simply effected by burying an iron rod in the core, having on it a cross at the end to give it a hold of the sand, the outer end being locked to a transverse piece which bears on the edges of the box.

The metal requires to be at a high temperature for hollow moulding; for so quickly does it cool, that the brim of a moderately sized pot *sets* even before the mould is filled. While yet red hot, the casting is taken out of the sand, and the gate piece knocked off. This must be done at a certain stage of the cooling, as when too soon done, the gate does not break clearly off; and when delayed too long, it often carries out a piece of the bottom of the pot with it. With a view so far to provide against this, the pot is made considerably thicker at the centre of the bottom. Flat gates are formed for flat bottomed ware—frying pans, for example. They are wide at the mouth to receive the iron the better, but taper like a wedge, towards the moulding, so as to be easily separated from the casting. By being of considerable extent, flat gates conduct the metal more speedily to the different parts of the mould.



Here are represented the forms of the cast-iron sleekers, employed in the operations of hollow moulding. Nos. 1 and 2, show the convex and concave sleekers for corresponding surfaces. Nos. 3 and 4, are tools with double plane surfaces, at certain angles with each other. Of these there is a variety, having their planes at different angles to suit the various salient and retreating angles that occur in mouldings. No. 5, is a sleeker for the impressions of beads; and No. 6 serves to smooth flat surfaces generally. All these have small studs attached to them which serve for handles.

(To be continued.)

## *Description of Mr. Clay's New Process for making Wrought Iron direct from the Ore; as practiced at the Shirva Works, Kirkintillock, Scotland.* By WILLIAM NEALE CLAY.

In this communication, the author first describes the various stages through which the metal passes, between the reduction of the ore, and its arriving at the state of malleable iron, by the ordinary mode of manufacture; and then he explains the process which he has invented, and introduced practically at the Shirva Works.

By the ordinary system of iron-making, the ores are reduced into the state of carburet of iron, and then, by refining and puddling, the metal is de-carburetted, thus making it into malleable iron by a number of processes, which are recapitulated:—

1st. Calcining the ore.

2nd. Smelting in a furnace, by the aid of blast, either cold or heated, with raw coal, or coke, for fuel, and limestone as a flux.

3rd. Refining the "pig" into "plate" iron.

4th. Puddling, shingling, and rolling, to produce the "rough," "puddled," or No. 1 bars.

5th. Cutting up, piling, and rolling, to produce "merchant," or No. 2 bars.

6th. A repetition of the same process, to make "best," or No. 3 bars.

Seeking to diminish the number of manipulations, by the new process a mixture of dry Ulverstone, or other rich iron ore, (Hæmatite) is ground with about four-tenths of its weight of small coal, so as to pass through a screen of one-eighth of an inch mesh. This mixture is placed in a hopper, fixed over a preparatory bed, or oven, attached to a puddling furnace of the ordinary form. While one charge is being worked and balled, another gradually falls from the hopper, through the crown, upon the preparatory bed, and becomes thoroughly and uniformly heated; the carburetted hydrogen and carbon of the coal, combining with the oxygen of the ore, advances the decomposition of the mineral, while by the combustion of these gases, the puddling furnace is prevented from being injuriously cooled. One charge being withdrawn, another is brought forward, and in about an hour and a half, the iron is balled, and ready for shingling and rolling. The cinder produced, is superior in quality to that which results from the common system; it contains from 50 to 55 per cent. of iron, and is free from phosphoric acid, which frequently exists, and is so injurious, in all the ordinary slags: when re-smelted, it produces as much No. 1 and No. 2 cast-iron, and of as good quality, as the ordinary "black band" ore of Scotland. The cast-iron produced from the slag (amounting to one-third of what was originally contained in the ore), is mixed with the ore and coal in the puddling furnace; and thus, while nearly all the iron is extracted from the ore, as much wrought iron is produced in a given time, and at the same cost of fuel, as by the old system. The first process, producing puddled bars of superior quality, is, consequently, on a par with the fourth stage of the old system, as it avoids the necessity of the preceding separate manipulations. From the absence of all deleterious mixture, by once piling and re-heating the rough bars, iron is produced, of a quality in every respect equal, and in powers of tension, superior, to that which results from the second piling and reheating in the common mode; it is, therefore, contended that the two processes produce from the hæmatite nearly one-third more iron, of as good a quality as is usually obtained by the six processes of the old system. The iron thus produced bears a high polish, is very uniform in its texture, is ductile and fibrous, having more than an average amount of tensile strength, and at the same time appears to be more dense, as it possesses a peculiar sonorousness, resembling that of a bar of steel when struck. It has also been converted into steel of a good quality.

The paper is illustrated by a drawing of the furnace necessary for the process, and by specimens of the iron and steel produced.

*Remarks.*—Mr. Clay contended that the ordinary method of making iron was neither so scientific, nor so practically good as there was reason to expect it would have been, when iron formed so considerable an item in the productive industry of the country. His invention was in some degree based upon the old Catalan fire, wherein malleable iron was produced direct from the ore, although by a considerable expenditure of fuel: by his process the ore was also reduced at one operation into the state of malleable iron, by combination with a large portion of carbonaceous matter; and as the deoxidation of the ore could proceed simultaneously in an adjoining preparatory bed, through which the flame of the puddling furnace traversed, there was necessarily a great saving of time, labor, and fuel in the production of the metal, while the quality was at the same time improved. He argued, therefore, that if the system was generally adopted, a large portion of the capital now sunk in the expensive constructions of blast furnaces, blowing engines, &c., would be dispensed with.

Mr. Taylor observed that the process appeared to be only applicable to the rich qualities of iron ore, which were now used in comparatively small quantities, as a mixture with the clay iron stones of the coal fields, from which iron was generally produced in this country. There existed large quantities of hæmatite in Great Britain, equal in quality to that of Nassau, or of the Hartz mountains, from which so much iron was made, for converting into steel. The mines of Ulverstone alone now produce 50,000 tons annually, and at least 25,000 tons more could be shipped from Cornwall; and if a demand existed, there was scarcely a limit to the quantity that could be raised. He apprehended that the iron made by this process could be converted into good steel: this was very desirable, as it would render this country independent of Sweden and Russia, whence nearly all the steel-iron was now imported.

Mr. Heath had examined Mr. Clay's process of iron making, and found that the wrought iron produced from a mixture of Scottish pig-iron, and hæmatite ore, was of a superior quality, bearing severe tests without injury. The iron made by this method, from India pig-iron and specular iron ore (per-oxyde of iron) from Devonshire, which was identical in quality with the celebrated Elba ore, when converted into cast steel, by a process which he had accidentally discovered, possessed the quality of welding like shear steel, without any of its defects. The method he alluded to, was to combine manganese with the cast steel in the crucible, and when drawn out under the tilt hammer it could be worked and welded to iron, like shear steal: the consequence of this discovery was, that the latter quality of steel was almost abandoned for cutlery, and the former was now generally used, as it did not exhibit the laminated appearance when polished, which shear steel frequently did. The metal was sounder, and fewer wasters were made. All the brown hæmatites contained manganese, and there was little doubt that, by selecting the proper kinds of ore, malleable iron might be made in Great Britain by this process, as good for converting into steel as any of the Swedish iron. There was abundance of specular iron ore on Dartmoor, equal to the Elba ore, and which would (he had little doubt) produce as good iron as that from the Dannemora ore.

Dr. Faraday remarked that the process invented by Mr. Clay was founded on sound chemical principles. It was desirable to abandon the use of limestone as a flux: it was proved that the purest limestones contained phosphates, which, although advantageous in agricultural processes, were detrimental in iron making.

Mr. Fox had tried some specimens of Mr. Clay's iron, and found them to bear severe tests, as well as the best cable bolt iron made in the ordinary manner.

Mr. Clay explained that Mr. Heath's process was not indispensable for converting into steel the iron made by his method; and also that argillaceous iron ores, after calcination, could be treated in his furnace, like the hæmatite ores, but not so advantageously.

Mr. Taylor said that 25,000 tons of steel were converted annually in this country, and of that quantity not more than 2500 tons were made from the best Swedish iron; for the remainder, inferior qualities of iron, such as Russian iron, marked CCND, from the forges of Monsieur Demidoff, were used. All that iron was made with charcoal, and could only be called inferior, when compared with that made from the Dannemora ore. If Mr. Clay's process was successful in treating the hæmatite ores, as had been stated, it was of great importance, as it would emancipate the country from a dependence upon foreign products. He had recently seen in Germany, a process of producing steel by stopping the operation of puddling pig-iron at a certain point, or intermediate state between cast and wrought iron, and hammering the mass at once into bars. The operation was one of much delicacy, and depended entirely upon the skill of the workman.

Mr. Heath believed the manufacture of steel was involved in unnecessary mystery; it was the general opinion that foreign iron was essential to produce good qualities. Iron as now made from coke furnaces, certainly contained too much foreign matter to be used for steel, and it would require more attention to the selection of the materials, before pure iron could be obtained; some of the Low Moor iron, the good quality of which was universally admitted, had been made into blistered steel, but although the springs made with it appeared perfect, it was said that they did not answer so well as those made with steel from charcoal iron. The Sheffield manufacturers required that steel should possess "nature and body;" the first quality to enable it to be rolled and drawn out without cracking, and the second, that it might receive and retain a fine edge. Steel made from Garnderris iron (South Wales) possessed "nature," but if made into cast-steel, it fled into pieces in working, as it did not possess "body." Steel from German ores appeared to have "body," but wanted "nature." Steel from Indian iron, although difficult to work, stood better than other kinds when once reduced into form; this he attributed to the purity of the magnetic ore from which it was produced; there was not the slightest trace of phosphorus, arsenic, or any deleterious foreign matter. He was convinced that, with a mixture of Indian pig-iron (which could be produced very cheaply) and Devonshire ore, by Mr. Clay's process, iron could be made of excellent quality for converting into steel at such a reduced price, as would render the introduction of Swedish and other foreign iron unnecessary.

Mr. Taylor believed that improvements in the quality of steel, rather than reduction in the price, was the object sought. In the large quantity used in the mines under his direction, the dearest steel was found to be the more economical. He had seen as many as 12 dozen borers used to make one blast hole, and unless the tools kept their points well, the labor of the men was thrown away.

Civ. Eng. & Arch. Journ.

## *On the Perfect Ventilation of Lamp Burners.*

In consequence of the injury sustained by the books in the library at the Athenæum Club, amounting almost to the entire destruction of the bindings; and the complaints of the members of the vitiated state of the air in the rooms, causing headache, oppressive breathing, and other unpleasant sensations; Professor Faraday's attention as a member of the club, was drawn to the subject of ventilating lamp burners in houses; and he was induced to suggest the trial of various plans, for affecting the removal of the products of combustion, produced by sources of artificial light. All substances used for the purpose of illumination, may be represented by oil and coal gas; although tallow and wax are also greatly employed, yet as until they are rendered fluid like oil, they cannot be burnt, they may for all practicable purposes be classed with it. Now, oil and gas both contain carbon and hydrogen, and it is by the combination of these elements with the oxygen of the air, that the light is evolved. The carbon produces carbonic acid, which is deleterious in its nature, and oppressive in its action in closed apartments, and the hydrogen produces water. A pound of oil contains about 0.12 of a pound of hydrogen, 0.78 of carbon, and 0.1 of oxygen; when burnt it produces 1.06 of water, and 2.86 of carbonic acid, and the oxygen it takes from the atmosphere is equal to that contained in 13.27 cubic feet of air. A pound of London coal gas contains, on an average, 0.3 of hydrogen, and 0.7 of carbon; produces when burnt, 2.7 of water, and 2.56 of carbonic acid gas; consumes 4.26 cubic feet of oxygen, equal to the quantity contained in 19.3 cubical feet of air. So a pint of oil, when burnt, produces a pint and a quarter of water; and a pound of gas produces above 2½ pounds of water; the increase of weight being due to the absorption of oxygen from the atmosphere, one part of hydrogen taking eight by weight of oxygen, to form water. A London Argand gas lamp, in a closed shop window, will produce in four hours, two pints and a half of water, to condense or not, upon the glass or the goods, as it may according to other circumstances happen; also, a pound of oil produces nearly three pounds of carbonic acid, and a pound of gas, two and a half pounds of carbonic acid. Now, carbonic acid is a deadly poison, an atmosphere containing even one-tenth of it, is soon fatal to animal life. The various accidents from lime and brick kilns, from brewers' vats, occasionally from the sinking of wells, as at Cheltenham, and from the choke damp in coal mines, attest the extreme danger contingent upon the presence of this substance. A man breathing in an atmosphere containing 7 or 8 parts of carbonic acid, would suffer, not from any deficiency in oxygen, but from the deleterious action of the carbonic acid. M. Leblanc has recently analyzed carefully the confined air of inhabited places, and concludes, as stated in his *Memoire*, that the proportion of carbonic acid gas in such places, may be regarded as measuring with sufficient exactness, the insalubrity of the air; that in the proportion of one part to a hundred of air, ventilation is indispensable for the prevention of injury to the health; that the proportion of carbonic acid gas had better not exceed a five hundredth part, though it may rise without inconvenience, to a two-hundredth part. If a lighted taper be applied to the top of a lamp chimney, it will be instantly extinguished, or a glass jar held over it will become immediately filled with air, in which a light cannot burn. Also sulphurous and sulphuric acid, are contained in the water which results from the combustion of coal gas, and are products injurious to metals and articles of furniture.

It will now be understood, that the object sought to be obtained in the ventilation of lamp burners, is the entire removal of all the noxious products of combustion. And with this view, at Professor Farraday's suggestion, the gas lights of the chandelier in the library of the Athenæum, were ventilated by pipes dipping into the lamp glasses, and conjoining at a short distance upwards into one central pipe, which carried away all the burnt air out of the room. In this first practical experiment, many things were learned as to the mode of arranging the pipes; the disposal, when the pipes were very long, of the water produced, &c.; but the objects sought for by the ventilation, were at once and perfectly obtained. This principle may be illustrated by a simple experiment, showing the difference between allowing combustion to give its products to the air of a room, and carrying off these products as soon as formed to the exterior; let a short wax candle be placed burning on a plate, a glass jar put over it, and the upper aperture of the jar closed by a globular cork, through which passes a piece of glass tube, about half an inch in diameter, and twelve or fourteen inches long; the tube descending to the top of the candle flame, and being placed just above it. Under these circumstances there will be plenty of air passing into the jar, between it and the plate, and out by the tube, to supply all that is needed for combustion, and keep the glass chamber sweet; the consequence is, that in this position it will go on burning for any length of time, and the jar remain quite clear and bright; but on moving the cork a little, so that the tube shall no longer be over the flame, all these results will change, though the air-way remains exactly as before. The candle will now give the products of its combustion to the general air of the glass chamber, the glass will immediately become dull, from water deposited upon it, the air itself will become worse and worse; the light become dim, and in a few minutes will go out. But if arrested from doing so by the tube being again placed over it, signs of recovering will appear, the light will return to its former brightness, and after a short time, even the dew will disappear from the glass; all in consequence of the proper ventilation of the light. These effects, though striking, may easily be understood by any one who will think of the difference of lighting a fire in the middle of a room, instead of under, or in right juxtaposition to a chimney.

Then came the desire of modifying the system, by removing the ascending flue from its place over the lamp, not from any deficiency in action, but for appearance sake only; and finding that there was sufficient ascension power in the main part of the metal chimney, to allow of a descending draught over the lamp, the tube, in place of going directly upwards, was made to turn short over the edge of the glass, to descend to the area or bracket, to pass along it, and then ascend at the central part of the chandelier, or against the wall if applied to a single light. To this succeeded another form, which is exceedingly beautiful, and appears to be the perfection of lamp ventilation. It is, in fact, a beautiful application of the principle of a descending draught to a lamp burner. The gas light has its glass chimney as usual, but the glass holder is so constructed as to sustain not merely the chimney, but an outer cylinder of glass, larger and taller than the first; the glass holder has an aperture in it, connected by a mouth-piece with a metal tube, which serves as a ventilating flue, and which, after passing horizontally to the centre of the chandelier, there ascends to produce draughts, and carry off the burnt air.

The burnt air and results of combustion, take the course indicated by the arrows, and are entirely carried away by the chimney. Now with a lamp burning in the ordinary way, the products of combustion issue out as a torrent of ærial impurity from above, but if the above arrangement be applied, on closing the top of the outer glass cylinder by a plate of mica, all the soot, water, carbonic acid, sulphurous and sulphuric acid, and a portion of the heat, are entirely carried away by the ærial sewerage, and discharged into a chimney, or the open air, and the air in rooms may thus be kept in the same sweet and whole-some condition, and fit for the purposes of respiration, as if artificial light were not being used.

Fig. 1.—*a*, is the burner; *b*, the gas pipe leading to the burner; *c*, the glass holder, with an aperture in it opening into the mouth-piece *d*, which is attached to the metal chimney, *i*; *e*, the ordinary glass chimney; *f*, an outer cylinder of glass closed at the top by a plate of mica, *g*, or still better, by two plates of mica, one resting on the top of the glass, and the other one, *h*, dropping a short way into it; they are connected together by a metal screw and nut, which also keeps them a little apart from each other, thus forming a stopper which cannot be shaken off the glass chimney, but is easily lifted on and off by the small metal ring or knob at the top; *i*, is the metallic tube chimney; *k*, a ground globe, which may be applied to the lamp, and which has no opening except the hole at the bottom, where it rests on the glass holder; but any other form, as a lotus glass, or a vase, may be substituted at pleasure.

Fig. 1. Fig 2.

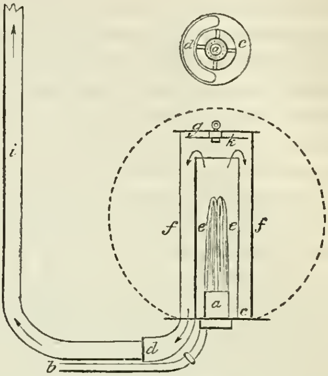


Fig. 2, is a plan of the glass holder, showing the burner, *a*, in the centre, perforated with jets, with openings round it to allow of a free admission of air to the flame, and the aperture *d*, which opens into the mouth-piece, connected with the metal chimney, *i*.

A curious but important result of the inclosed lamp, is the increase of light produced, amounting to from 10 to 20 per cent., according to circumstances, the same quantity of gas being consumed as before. If the current of air through a lamp glass, when the gas is burning in the usual manner, be diminished, the flame rises in height, and the light is increased in amount, but is of a redder color; the combustion in fact is not so intense, because the access of air is retarded; the particles of carbon which give the light, are not so highly ignited, but are more abundant, and are ignited for a *longer time*, thereby causing an increase of light.

The advantages of the above plan are many; it is not in the least objectional in architectural appearance, the ventilation is perfect, the heat given to a room is modified and pleasant, and may be either sustained or diminished at pleasure; the light, for good philosophical reasons, is increased considerably for a given portion of gas, and increased safety from accidents is obtained; as in the event of any leakage from the pipes, or from a gas cock being inadvertently left open, the gas, instead of mixing with the air of the room, and becoming explosive, would be almost inevitably carried off by the metal tubes.

We understand that Prof. Faraday has transferred his right to this invention, to his brother, a gas-fitter, who has secured it by a patent.

Civ. Eng. & Arch. Journ.

### *Retrospect of the Progress of Aerial Navigation, and Demonstration of the Principles by which it must be governed.* By Sir George Cayley, Bart.

*Sir,*—Within the last six months there has been considerable excitement evinced, respecting a scheme for transporting men and goods through the air, by mechanical means, without the aid of balloons to sustain the weight intended to be thus conveyed. The proposal was announced in so decided a manner, and in such startling terms, that in these days of mechanical wonders, some are disposed to give full credence to the practicability of the undertaking, and others to reject it as a visionary hoax on public credulity.

About thirty years ago, the subject of ærial navigation by mechanical means was much canvassed, and several papers were published on it in Nicholson's Chemical Journal, the Philosophical Magazine, &c. Many experiments, as to the means of support, and the stability and guidance of such machines, were then made on a large scale, some of the experimental vehicles having from three to four hundred feet of canvas extended on masts, and braced by rigging, to give strength and precision of position to their surfaces. These trials proved in the most decided manner, that perfect stability and guidance were effected, and that the means of support, to a certain limited extent, were attainable. For instance, it was proved that a man placing himself in a machine of proper dimensions for his weight at the top of a mountain, say one mile above the level of the plain below, might, in calm weather, with steadiness and security proceed through the air to any place to which he might choose to steer himself, about eight miles in horizontal measure from the point of his departure. Of course, in this case the line of flight must be in a continued descent of one in eight, and gravitation is the only cause of the progress of the machine; the case, being, in some measure, similar to that of a carriage running down hill without horses. If, instead of this machine being allowed to descend in its path by gravity alone, the man had applied his power to propel it, by revolving oblique fliers, or other suitable means of waftage, he might probably have extended the distance from eight to twelve or fifteen miles; but the muscular strength of a man is not sufficient to maintain a horizontal path, unless it be for a very short time.*

To render ærial navigation by mechanical means alone, efficient, some first mover is required, which combines great force with little weight. The steam engine, in any of those permanent forms, calculated for real service, together with the water and fuel it requires, would probably be found inconveniently heavy for the purpose, if not absolutely inefficient,* and I believe it was this consideration, coupled with the serious expense of ascertaining the fact practically, which, at the date I have alluded to, operated as a check to future inquiry on the subject. When, however, a lighter first mover should be invented, every other part of the apparatus was in readiness to meet the discovery, and realize the scheme.

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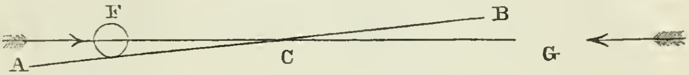
* Many years ago, Mr. Degen, who was a prisoner at Vienna, by means of large surfaces formed like umbrellas, succeeded in elevating himself fifty feet, as measured by a cord which was attached to his machine by the goaler for safe custody, but at the expense of the total exhaustion of his muscular strength in a couple of minutes. A man, when running up stairs for a few seconds, is exerting the ordinary power of two horses—being twelve times greater than the power he can use with permanent effect.

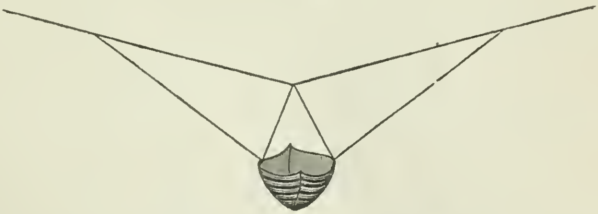
As the principles of ærial navigation, by mechanical means, are few and simple, a recapitulation of them at the present moment may not be unacceptable to your readers, and may enable them to judge more correctly of the project I have alluded to, when more distinctly presented to the public.

Fig. 1.



The leading principle of ærial navigation, is that of the inclined plane. Suppose A B, fig. 1. to represent an inclined plane, rising one foot in ten; it is well known that if the ball F, weighs 100 lbs., a force of 10 lbs., applied horizontally, would sustain it from rolling back. Conceive the same line A B, to represent, also, the section of a large surface, like the sail of a ship, and that C G represents a cord by which it is sustained from being driven back by a horizontal wind blowing in the adverse direction. If the sail contains 100 square feet of surface, and the wind has sufficient power to press with one pound to the foot, 100 pounds weight will be supported, and the tension on the cord will be only 10 lbs. It is the same thing whether the wind thus blows against the sail, or the sail be driven, with equal velocity, horizontally in calm air; the 10 lbs. propelling power, will still sustain the 100 lbs. in the air. It is difficult to ascertain the precise angle used in the wings of birds; but one in ten certainly exceeds that of most birds, and probably one in sixteen is nearer the truth.

Fig. 2.



The stability of these machines is maintained laterally, by making the surface in its cross section, as represented in fig. 2. By this means, the side that comes down in any heel of the vehicle, meets a *greater* resistance, whereas, that which has necessarily gone up, meets with *less*, and this contrary action, operating on a large extent of leverage from the centre, immediately restores the proper position. The distance of the centre of gravity G, below the centre of support, also tends greatly to increase this power, and mainly contributes to the stability of the machine in the line of its path. This, however, is also aided by the adaptation of a horizontal rudder, like the fan tail of birds, used for the purpose.

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* The water used in the high pressure tubular boilers, amounts to about 70 pounds per horse power per hour, the fuel about 10, so that the food of the steam horse is about 80 per hour. The engine itself, if of the lightest efficient structure, may weigh about 150 lbs. to the horse power. If the steam were condensed again, by exposure within extended surfaces to the cooling influences of the current of air, no larger supply of water would be required; but such extended surfaces are inconvenient, and add greatly to the weight.

The side guidance is perfectly effected by a rudder in a vertical plane, as in the case of ships, and elevation and descent are produced, in ordinary cases, by having the command of the horizontal rudder already noticed; but when progressive motion is not required, and the ascent or descent is to be made perpendicularly, then the effect is produced by the power being applied to extensive oblique vanes, or fliers, which, when not employed in this way, are so made as to become flat, and thus form the surfaces already described. The progressive impulse is most readily obtained by smaller oblique vanes, like the screw propellers in boats, worked by the power of whatever engine is employed; or the oblique wing waftage, as is used by birds, may be employed.

The real question rests now, as it did before, on the possibility of providing a sufficient power with the requisite lightness. I have tried many different engines as first movers, expressly for this purpose. Gunpowder is too dangerous, but would, at considerable expense, effect the purpose; but who would take the double risk of breaking their necks, or being blown to atoms? Sir Humphrey Davy's plan of using solid carbonic acid, when again expanded by heat, proved a failure in the hands of our most ingenious engineer, Sir M. Isambard Brunel.

As all these processes require nearly the same quantity of caloric to generate the same degree of power, I have for some time turned my own attention to the use, as a power, of common atmospheric air expanded by heat, and with considerable success. A five-horse engine of this sort was shown at work to Mr. Babbage, Mr. Rennie, and many other persons capable of testing its efficiency, about three years ago. The engine was only an experimental one, and had some defects, but each horse power was steadily obtained by the combustion of about 6½ pounds of coke per hour, and this was the whole consumption of the engine, no water being required. Another engine of this kind, calculated to avoid the defects of the former one, is now constructing, and may possibly come in aid of balloon navigation—for which it was chiefly designed—or of the present project, if no better means be at hand.

London, March 25. Mechanics' Magazine.

## *Hot-Blast Case*—Neilson's *Patent.*

After a long trial of ten days, unprecedented, we believe, in the annals of the Jury Court of Scotland, a verdict was returned in favor of the pursuers, at six o'clock on Saturday evening, the particulars of which will be found subjoined. The following is a copy of the issues:—

*Issues in the Cause* in which James Beaumont Neilson, of Glasgow, engineer, Charles M'Intosh, formerly of Crossbasket, now of Campsie, John Wilson, formerly manager of the Clyde Iron Works, now of Dundyvan, for themselves; and James Oswald, of Shieldeall, now one of the members of Parliament for the city of Glasgow, James Dunlop, jr., merchant in London, brother-german of Colin Dunlop, after designed, Andrew Bannatyne, writer in Glasgow, Charles M'Intosh, aforesaid, James Dunlop, formerly of Fludyer street, Westminster, now residing at Clyde Iron Works, nephew of the said Colin Dunlop, and John Wilson, aforesaid, as trust-disponees of Colin Dunlop, formerly of Clyde Iron Works, thereafter of Tolcross, now deceased, conform to his trust-disposition, and deed of settlement in their favor, dated the 29th day of January, in the year 1834, and two codicils thereto, dated respectively the 29th day of June, 1836, and 29th day of May, 1837, which trust-disposition and codicils are all recorded in the Sheriff Court books of Lanarkshire, the 27th day of September. 1837, as also executors *nominate* of the said Colin Dunlop, conform to confirmed testament in their favor, expede before the Commissary of the Commissariot of Lanarkshire, of date the 18th day of April, 1838—are *pursuers*;—and

Messrs. William Baird, Alexander Baird, James Baird, Douglas Baird, and George Baird, carrying on business in partnership at Gartsherry Iron Works, in the parish of Old Monkland, under the firm of William Baird and Company—are *defenders*.

It being admitted that, on the 1st day of October, 1828, the pursuer, James Beaumont Neilson, obtained letters patent under the Great Seal used in Scotland, in place of the Great Seal thereof, and duly enrolled a specification, in terms of the proviso contained in the said letters-patent, being Nos. 30 and 31 of process;

It being also admitted that the pursuers, other than the said James Beaumont Neilson, have acquired, by assignment from him, a joint interest in the said patent;

Whether, in the course of the year 1840, and between the 27th day of March, and the 7th day of May, in the said year, and during the currency of the said letters-patent, the defenders did, in, or at their iron works at Gartsherry, by themselves, or others, wrongfully, and in contravention of the privileges conferred by the said letters-patent, use machinery, or apparatus, substantially the same with the machinery, or apparatus, described in the said specification, and to the effect set forth in the said letters-patent and specification, to the loss, injury, and damage of the pursuers?

Or,—1. Whether the invention, as described in the said letters-patent and specification, is not the original invention of the pursuer, the said James Beaumont Neilson?

2. Whether the description contained in the said specification is not such as to enable workmen, of ordinary skill, to make machinery, or apparatus, capable of producing the effect set forth in the said letters-patent and specification?

3. Whether machinery or apparatus, constructed according to the description in the said letters-patent and specification, is not practically useful for the purposes set forth in the said letters-patent?

July 5, 1842. (Signed) D. Boyle, I. P. D.

The damages are laid as under—

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|---|---|
| Profits claimed, as at the date of action, | £10,000 |
| Other damages, as at the same date, | 10,000 |
| Total damages laid, | £20,000 |

*Edinburgh, March* 4, 1843.

The Lords having heard counsel on the respective motions for the parties, ordain the minutes for the pursuers, dated 4th July, and 16th November, both last, Nos. 46 and 52 of process, to be engrossed on the issue in this case as relative thereto.

(Signed) D. Boyle, I. P. D.

*July* 4, 1842.—Rutherfurd, for the pursuers, stated to the court, he agreed that, under the first issue, it shall be competent to the defenders to try the issue of public use.

(Signed) And. Rutherfurd.

*Nov.* 16, 1842.—Rutherfurd, for the pursuers, agreed that it should be competent for the defenders, in the trial of the issues, as adjusted in this case, to state any objection, in point of law, to the validity of the patent, and relative specification, founded on the nature of the claim and statement there made on the part of the patentee, and that the court should decide the same, by way of direction, in the course of the trial. (Signed) And. Rutherfurd.

The case for the pursuers was opened before the Lord President, and a special jury, in the First Division of the Court of Sessions, on Wednesday, the 10th current.

The Lord Justice General and a special jury commenced, on Wednesday, the 10th of May, to try the above issues in this cause, which may be described as the most important of modern times in this country—whether we consider the vast interests at stake, or the great field of inquiry necessarily comprehended in testing the rights of the respective parties. In the words of the Lord Justice General, in addressing the jury, it was "an unparalleled trial—a trial which has embraced a more expensive body of evidence on both sides, and has occupied more of your attention, than any cause with which I am at all acquainted in this court." This trial occupied ten days, commencing, as we have stated, on Wednesday, May 10, and not terminating until Saturday, the 20th. The question regarded the validity of the patent obtained by Mr. Neilson, in October, 1828, "for the improved application of air, to produce heat in fires, forges, and furnaces, where bellows and other blowing apparatus are required." In short, Mr. Neilson proposed that the blast should be heated in its passage from the blowing apparatus to the furnace, and delivered hot, instead of cold, as formerly practiced. This was to be accomplished by placing one or more vessels, or air receptacles, between the blowing apparatus and the furnace, and heating those vessels externally in a considerable temperature. "It is better," says the patentee, in his specification, "that the temperature be kept to a red heat, or nearly so; but such a temperature is not absolutely necessary to produce a beneficial effect." When this invention was first made public, it was received with general distrust, and even ridicule; the prevailing, indeed, universal, opinion in the scientific world, and among the iron-masters, both in this country and abroad, having been, that the blast could not be too cold when it entered the furnace. This opinion was so far supported by the practical experience of the time, it having been remarked that the iron smelted better in winter than in summer. These prejudices were, however, dispelled as soon as Mr. Neilson's invention was seen in operation, and producing such prodigious results in the production of iron. Such was the power of hot-blast in the fusion of the materials in the furnace, that the product was doubled—*i. e.* a furnace produced as much in twelve hours with the hot-blast, as it had done in twenty-six hours with the cold. Talking generally, it was also found that this beneficial result was accomplished with one-half less fuel, and one-third less flux, or limestone. As regards Scotland, the great advantages of this invention were manifested in a remarkable degree. In 1828, or before the patent, the total quantity of iron produced in Scotland in one year, was about 60,000 tons; in 1840, the total quantity had risen to about 300,000 tons, being five times the product of 1828. This vast advance was mainly, if not exclusively, attributable to the hot-blast, which had entirely superseded the cold—not a single furnace in Scotland being worked, in 1840, or at the present time, by the cold-blast, with the exception of one at the Carron Works, and which is for their own exclusive use, the pig-iron produced thereby not entering the market. Another important illustration of the advantages of Mr. Neilson's invention, was its effect on the English iron market. In 1830, the total imported iron at Liverpool was 8980 tons, of which there was from Clyde, or Scotland, 3180 tons; in 1841, the total import at the same port was 37,304 tons, of which from Clyde, 30,899; in 1830, the total import of iron at Runcorn, (the other great emporium in England, of the iron trade,) was 3974 tons, of which from Clyde, there were only 11 tons; in 1841, the total import from Runcorn, was 18,161 tons, of which from Clyde, or Scotland, there were 14,306 tons—and every ton of which was, of course, manufactured by the hot-blast, there being then no cold-blast furnaces in operation in Scotland.

During the greater part of the currency of the patent, which lasted from October, 1828, to October, 1842, all the iron-masters in Scotland, and also those in England, who adopted the hot-blast, took out licences from the patentee, paying 1*s*, per ton, of iron smelted by them for the use of the invention. Latterly, however, the patent has been challenged, both in England and Scotland, and on various grounds. It was stated by the counsel of Mr. Neilson, at this trial, that he had as yet succeeded in establishing his patent, having triumphed in every instance, and obtained damages from the parties working the hot-blast without his license, and who were thereby declared to have wrongfully used his invention, or invaded his patent. In these actions, as in the present, against the Messrs. Baird, of Gartsherrie, the defences resolved into various allegation. It was argued at this trial, that the patent was void, as being only for a principle; or, in other words, it stated, in effect, that hot air was better for smelting iron than cold air, without fulfilling the conditions of the law, by clearly specifying the practical mode in which this was to be accomplished; that, in fact, the patent merely embodied a principle, without clothing that principle with any practical effect, in order to render the patent valid. Further, assuming that the specification did profess to set forth a practical mode of executing the invention, still the patent was alleged to be void, because this mode, if followed, would lead to a false, or impracticable, result. Then it was alleged that Mr. Neilson was not the original inventor, seeing that the hot-blast had been practiced at other places, and that it was publicly known previous to the date of the patent. This did not imply, and the Lord Advocate, as leading counsel for the Messrs. Baird, disclaimed the idea, that Mr. Neilson had borrowed the discovery from another, but, simply, that the invention might be original as regarded the merit of Mr. Neilson, but still not the subject of a patent, if it turned out that it had been previously known, and publicly used, or disclosed by others, though such prior discovery was totally unknown to Mr. Neilson. The validity was also challenged, in respect that the directions in the specification would not, as the law requires, enable workmen of ordinary skill in such matters, to construct an apparatus useful for the purposes set forth in the patent.

The Dean of the Faculty of Advocates, (Patrick Robertson, Esq.,) detailed the whole circumstances of the case, and the various proceedings in the Court of Session, and House of Lords. He contended for the validity of the pursurer's patent—he undertook to prove that the defenders, by themselves and others, had invaded, or taken advantage of, it, whereby they had made great gains, or profits, and that they were justly liable to make reparation to the pursuers. He concluded a brilliant speech, which occupied nearly six hours, by calling upon the jury to find accordingly.

Evidence was then led in support of the issues for the pursuers, which occupied the court from Wednesday till the Monday following. This evidence consisted of practical and scientific men from all parts of the kingdom. At its conclusion,

The Lord Advocate of Scotland, (Duncan M'Neill, Esq.,) opened the case for the defenders, in a masterly speech of five hours, in which he analyzed the evidence of the pursuers, and undertook to prove that the pursuer, Mr. Neilson, was entitled to no credit for his invention, because the hot-blast, for which he obtained the patent, was in use, and well known, before the date of it; that the patent itself was void in law, and that no damages were exigible by him, or by the pursuers, from the defenders. The evidence led by the defenders in support of the defence occupied the court from Tuesday till the afternoon of Friday.

A. Rutherfurd, Esq., (late Lord Advocate of Scotland,) then replied on the evidence, and on the whole case of the pursuers. His speech, which occupied four hours in the delivery, was clear, forcible, and lucid; he called upon the jury to protect his clients, whose legal and just rights had been invaded by the defenders amongst others, and to give exemplary damages under the issues.

The court then adjourned till the following day (Saturday).

The Lord President having resumed his seat on the bench, by half-past twelve o'clock, proceeded to charge the jury in a luminous, straightforward, and able manner. His Lordship's address occupied three hours and a half.

The Lord Advocate, on behalf of the defenders, having taken several exceptions to the views of the Lord President, the jury retired at half-past four, and, at six o'clock, returned, in effect, the following *Verdict*, unanimously finding in favor of the pursuers in all the issues: awarding 7000*l.* of damages, and 4867*l.* 16*s.* for profits—making in all, 11,867*l.* 16*s.* The 4867*l.* of profits being on 4392 tons manufactured within six weeks, the period specified in the present action.

*Counsel for the Pursuers.*—The Dean of Faculty (Patrick Robertson, Esq ,)Andrew Rutherfurd, Esq., (late Lord Advocate) the Solicitor-General, (Adam Aderson, Esq.,) and John Inglis, Esq., advocate. Edinburgh agents—G. and G. Dunlop, Esqs., W. S. Glasgow agents—Messrs. Bannatyne and Kirkwood.

*Counsel for the Defenders.*—The Lord Advocate, (Duncan M'Neill, Esq.,) Robert Whigham, Esq., Charles Neaves, Esq., P. Mure M'Credie, Esq. Edinburgh agents—Messrs. MacAndrew. Glasgow agents—Messrs. A. and A. Graham.

London Mining Journal.

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## *Steam-Boiler Explosions.* By J. A. Haswell.

*Sir,*—Within the last six months there have been three boiler explosions of a serious nature, in this county (Durham). One of these took place last Thursday (December 29th), at the Patent Rope Manufactory of Messrs. Rowland, Webster & Sons, Deptford, near this town, and deserves especially to be recorded in your *Magazine.*

The loss of life, and the destruction of property, in this case, may not place it amongst the very worst of accidents, but the peculiar nature of the explosion gives it a claim on your attention; and with your permission I will briefly state the facts connected with it.

The engine is a high-pressure one of 30 horse-power, and was worked by two cylindrical boilers, each 23 feet long, 5 feet diameter, pressed at 35 lbs. on the square inch. The boilers were in a good state of repair before the explosion; in fact, they might be considered as new. They were so connected together, as to have the benefit of three safety-valves, to 3⅜ inches diameter, and one 4 inches diameter. The engine had been working all day at full work, and was to continue working until 10 o'clock at night; but at 6 o'clock the engineman was instructed to ease the engine, to enable the foreman to disconnect some of the machinery in the mill; when one of the boilers blew up with a tremendous crash, carrying away the roof of the apartment in which it was placed, and effecting other serious damage to the premises. Two of the workmen were much injured, and remain in a very precarious state; another person received a slight injury; and had it been a minute longer in occurring, there would have been not less than 20 men and women directly above the boiler, who would undoubtedly have lost their lives.

A few minutes after the explosion took place, the foreman, and engineer, (both practical men) and myself, examined the boiler, and found it torn across the middle, and longways towards the fire, on the bottom.

The boiler remained in its seat. A part was thrown up, and came in contact with a large T beam, 12 inches each way, and 1½ inch thick. This was broken into several pieces, which were thrown about in various directions. The force required to break the beam would be enormous, possibly sufficient to prevent the boiler from rising out of its place. The plates of the boiler were perfectly clean, but appeared to have been red-hot. The feed shut-off valve was quite shut, which would have prevented the water from going into the boiler, had the feed-pump been in a working state. There was no appearance of water about the building, except about a gallon in the other end of the boiler, which would accumulate from the stream rushing out of the boiler.

The opinion of several practical men, drawn from these facts, is that the explosion resulted from a deficiency of water in the boiler; and that the small portion left in it had been decomposed by the overheated plates, which had instantaneously generated *hydrogen* gas, possessing all the explosive force of gunpowder.

When we have before us such disastrous events as these, where so many lives, and such an amount of property, are depending on the attention of an individual, we ought to do all in our power towards hastening the time when our legislature will see the necessity of adopting a system of examination, which shall prevent engines and boilers being under the management of any but those "who are well trained, intelligent, and properly behaved, engineers—men who know something more about an engine, than to put on and off the steam."

Parliament has made some steps towards preventing inexperienced men taking charge of pit-engines; and surely if it be thought necessary to use caution in one case, we have an equal right to expect that those who may have charge of railway, steamboat, and factory engines, should be placed under the same restrictions, and not left to the care of men whose fitness for their task is left to be judged of by persons whose first consideration is the payment of the least amount of wages.

Pract. Mech. & Eng. Magazine.

## *On the Electricity evolved by the Friction of Water and Steam against other bodies.* By Michael Faraday, Esq.

The object of the experiments related in this paper, is to trace the source of the electricity which accompanies the issue of steam of high pressure, from the vessels in which it is contained. By means of a suitable apparatus, which the author describes and delineates, he found that electricity is never excited by the passage of pure steam, and is manifested only when water is at the same time present; and hence he concludes that it is altogether the effect of the friction of globules of water against the sides of the opening, or against the substances opposed to its passage, as the water is rapidly moved onwards by the current of steam. Accordingly, it was found to be increased in quantity, by increasing the pressure and impelling force of the steam. The immediate effect of this friction was, in all cases, to render the steam or water positive, and the solids, of whatever nature they might be, negative. In certain circumstances, however, as when a wire is placed in the current of steam at some distance from the orifice whence it has issued, the solid exhibits the positive electricity already acquired by the steam, and of which it is then merely the recipient and the conductor. In like manner, the results may be greatly modified by the shape, the nature, and the temperature of the passages through which the steam is forced. Heat, by preventing the condensation of the steam into water, likewise prevents the evolution of electricity, which again speedily appears by cooling the passages so as to restore the water which is necessary for the production of that effect. The phenomenon of the evolution of electricity in these circumstances, is dependent also on the quality of the fluid in motion. more especially in relation to its conducting power. Water will not excite electricity unless it be pure; the addition to it of any soluble salt or acid, even in minute quantity, is sufficient to destroy this property. The addition of oil of turpentine, on the other hand, occasions the devolopment of electricity of an opposite kind to that which is excited by water; and this the author explains by the particles, or minute globules, of the water having each received a coating of oil, in the form of a thin film, so that the friction takes place only between that external film and the solids, along the surface of which the globules are carried. A similar, but a more permanent, effect is produced by the presence of olive oil, which is not, like our turpentine, subject to rapid dissipation. Similar results were obtained when a stream of compressed air was substituted for steam in these experiments. When moisture was present, the solid exhibited negative, and the stream of air positive electricity; but when the air was perfectly dry, no electricity of any kind was apparent. The author concludes with an account of some experiments in which dry powders of various kinds were placed in the current of air; the results differed according to the nature of the substances employed, and other circumstances.

Lond. Athenæum.

## *Notice of some New Methods of Gilding and Silvering by Immersion.*

### By M. A. Levol.

At the present time, when great attention is being directed to the processes of gilding by the moist method, it seemed to me not without interest to publish an account of some new methods for gilding, or of silvering, by immersion, more especially on account of the facility of their execution.

*Gilding on Silver.*—Silver is very easily gilt by means of the neutral protochloride of gold, to which an aqueous solution of sulphocyanide of potassium has been added until the disappearance of the precipitate which at first formed. The liquor thus obtained should possess a slightly acid reaction, and if it has lost it, by too considerable an addition of sulphocyanide, it should be again restored by a few drops of hydrochloric acid. In order to gild, the well-cleansed silver is immersed in this liquor, nearly boiling, and moderately concentrated, in which state it is kept, adding from time to time, hot water to replace that which evaporates. In this manner the inconveniences which would result from too great an accumulation of the hydrochloric acid, the presence of which is nevertheless useful in preventing the formation of an auriferous precipitate, which would otherwise take place at the high temperature employed, were the alkali predominant, are obviated.

*Gilding and Silvering on Copper, Brass, and Bronze.*—A solution of cyanide of gold, and that of cyanide of silver in cyanide of potassium, has been recommended for gilding and silvering under the influence of electric forces. I have found that the same solutions, when at a temperature near their boiling point, may also be employed for gilding and silvering by immersion. Their preparation would be somewhat expensive were it necessary to obtain them chemically pure: but this would not offer the least advantage, and the operation may be simplified and rendered much less expensive by treating either the chloride of gold, or the nitrate of silver (both should be neutral) with an excess of cyanide of potassium, so as to obtain the soluble double cyanides.*

Silver cannot be gilt by this process, but it will be seen above that the sulphocyanide of gold, and of potassium, gilds this metal extremely well.

The solution of cyanide of copper in cyanide of potassium does not copper silver even in contact with zinc; but it coppers this last metal perfectly, and in a very solid manner.

I may observe, in conclusion, that these processes, so advantageous from their always succeeding, and requiring but a few minutes for every preparation, unfortunately do not allow but of the application of a very thin layer of the precipitated metal. This inconvenience is common to all the processes by immersion.—*Journ. de Pharm. et de Chim.*, No. 3, March, 1842. Chem. Gazette.

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* As the cyanide of potassium is employed in a state of aqueous solution, and is very dear in the solid state, it is most advantageous to employ the mother-ley from the residue resulting from the calcination in a closed vessel of previously dried ferrocyanide of potassium. Its price then does not exceed a third of the commercial value of the double cyanide, and it might even be obtained at a still less price by the process indicated by Professor Liebig.

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## *Purification of Hydrochloric Acid of Commerce.* By M. LAMBERT.

This process occasions little expense, and requires but little time, so that those manufacturers who may employ it, will be able to send into the market hydrochloric acid chemically pure, and costing scarcely a few farthings more a pound than the ordinary acid. When the acid to be purified contains sulphurous acid, which is the most usual case, I add a little binoxide of manganese, the oxygen of which converts the sulphurous into sulphuric acid. As, however, it is almost impossible to avoid, in so doing, the formation of a little chlorine, I add a small quantity of protochloride of iron, or even iron filings, which absorbs the free chlorine.*

When the acid contains no sulphurous acid, I convey a known quantity into a tubulated retort, adapt a tube in form of an S to the tubulure, and to the mouth a Woulf's apparatus, the jars of which contain distilled water, and are surrounded by cold water.†

The apparatus thus arranged, I introduce, by means of the tube S, a quantity of sulphuric acid of spec. grav. 1.834, twice that of the hydrochloric acid. For this purpose, I employ a funnel, drawn out, which is fixed in a firm manner above the tube, and in which rests an inverted flask containing sulphuric acid, which allows of the operation going on alone. The sulphuric acid combines with the water and liberates the gas, which dissolves in the water of the jars. It is important to employ concentrated hydrochloric acid (spec. grav. 1.178;) without this precaution, the gaseous acid would not be evolved immediately, and it would be less easy to obtain the whole. When the whole of the sulphuric acid has been added, the liquid is heated gradually to boiling; it then contains no more hydrochloric acid. Thus obtained, the hydrochloric acid is chemically pure;‡ and in this operation, the expenses are reduced to the concentration of the acid, which, brought from 1.628 to 1.834, may serve again for the same purpose, and even for the less delicate operations in the arts, and of the laboratory. It might also be used in many cases just as it is, *i. e.* at 1.628; and lastly, a manufacturer of chemicals who would purify hydrochloric acid by this means, would not have to employ heat, in order to obtain the last portions of the gaseous acid, as the weak sulphuric acid, containing the hydrochloric acid, may be employed in the preparation of this latter.—*Journ. de Pharm.*, March.

Chem. Gazette.

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* When iron filings are employed, they must contain no copper, which would react on the sulphuric acid, and cause it to pass again into the state of sulphurous acid.

† I bring no water into the first jar, because at the end of the operation a small quantity of acid water passes over, and even of pure water, if the operation is carried too far.

‡ If the acid to be purified, contain arsenic, only the first portions are pure, and even then it is necessary that it should be concentrated at least to 1.178, to avoid the disengagement of any heat on the addition of sulphuric acid. This result is owing to the extreme volatility of the chloride of arsenic.

## *Galvanized Iron.*

About five years since a patent was taken out in this country, by M. Sorel, for the purpose of galvanizing iron, by a process of coating it with zinc, in a similar manner to tinning, but for some cause, we believe a dispute among certain capitalists, this patent has been allowed to remain in abeyance, during which period, it has been in considerable use in France, and is, at the present time, we understand, extensively employed by the French government. It is now taken up in this country by some spirited individuals, who have established large works in London for zincing iron to any extent. The process may be applied to both cast and wrought iron in any form.

"The effect of zinc in protecting iron from oxidation," says Professor Graham, "has been known to chemists for some time. When these two metals are in contact, an electrical, or galvanic, relation is established between them, by which the iron ceases to be susceptible of corrosion by dilute acids, saline solution, or atmospheric humidity. It was found in experiments lately conducted at Dublin and Liverpool, that small pieces of zinc attached to each link of a chain-cable, were adequate to defend it from corrosion in sea water. The protection was observed to be complete, even in the upper portion of the iron chains by which buoys are moored, (and which, from being alternately exposed to sea water and air, is particularly liable to oxidation,) so long as the zinc remained in contact with the iron links. The protecting influence of the zinc could not be more certainly secured than in the articles prepared by the patent process, the iron surface being uniformly coated over by that metal. In trials to which I have had an opportunity of subjecting them, the iron escaped untouched in acid liquids, so long as a particle of the zinc covering remained undissolved. The same protection is afforded to iron in the open atmosphere by zinc, with a loss of its own substance, which is inappreciably minute. The zinc covering has the advantage over tinning, that, although it may be worn off, and the iron below it partially exposed, the iron is still secured from oxidation by the galvanic action, while the smallest quantity of zinc remains upon it; whereas tin, in common tin plate, affords no protection of this kind, and not being absolutely impermeable to air and moisture, the iron under it soon begins to rust in a damp atmosphere. The simplicity and perfect efficacy of the means employed to defend iron from the wasting influence of air and humidity in this process of *zinc tinning*, certainly entitle it to be ranked as one of the most valuable economical discoveries of the age."

Civ. Eng. and Arch. Jour.

JOURNAL
OF
THE FRANKLIN INSTITUTE
OF THE
State of Pennsylvania,
AND
AMERICAN REPERTORY.

SEPTEMBER, 1843.

# Franklin Institute.

## COMMITTEE ON SCIENCE AND THE ARTS.

### *Report on the best modes of Paving Highways.*

The Committee on Science and the Arts, constituted by the Franklin Institute, of the State of Pennsylvania, for the promotion of the Mechanic Arts, to whom was referred the following portion of a joint resolution of the Select and Common Councils of the City of Philadelphia, passed January 5th, 1843, to wit: "Resolved, That the Franklin Institute, be requested to communicate to Councils, any information they may think proper, in relation to the best modes of paving highways," REPORT thereon as follows:

That they entered upon the subject referred to them, in February last, that, at various meetings since, they have discussed numerous questions connected with the subject of paving, and that they have received testimony relative thereto, from a number of persons whose opinions are entitled to respect, and who appeared, by request, before their sub-committee.

With the view of setting out the results of our labors with greater perspicuity, we shall divide the subject into eight sections, treating, in the first place, of the leading pavements in use, and, ultimately, of those which seem most suitable to Philadelphia, to wit:

Section I. *Preliminary Observations.*
" II. *Asphaltic Pavements.*
" III. *Wooden Pavements.*
" IV. *Stone Pavements.*
" V. *Pavements suitable to Philadelphia.*
" VI. *Plans and Specifications of the Pavements Recommended.*
" VII. *Superintendence and Mode of Executing the Work.*
" VIII. *Concluding Observations.*

Without entering particularly upon the subject of *footways*, we shall, in discussing the matter in hand, limit ourselves chiefly to a consideration of street pavements, fit for the internal intercourse of cities; neither do we propose treating of the merits of the various modes of constructing roads, since many of the maxims of roadway engineering, though extremely judicious, when applied to highways *between cities*, are, to a great degree, inapplicable to streets *within them.*

## SECTION I.

### *Preliminary Observations.*

Since the thirteenth century, when regular pavements appear to have been commenced, within the limits of the leading cities of Europe, numerous plans have been projected, by ingenious men, for the amelioration of the public streets, and not a few patents have been procured in France and England, having, for their objects, improvements in the constructions of pavements, or the application of new materials to that use.

But as it is not our intention, either to enter into the early history of paved roads, or to attempt a record of the innumerable projects, both useful and abortive, which have been from time to time brought forward for the improvement of highways, and, particularly, of streets; we shall dispense with historical detail, and confine ourselves to a discussion of those species of pavements which have, of late years, the most engaged public attention, or have been the most in use.

These may conveniently be divided into three general classes, namely, *Asphaltic Pavements*, *Wooden Pavements*, and *Stone Pavements.*

From these, our deliberations have led us to select certain modes of paving, which would seem to be proper for Philadelphia, and which, in due course, we shall come to describe.

*A good pavement ought to combine stability, and moderate smoothness of surface, with facility of removal and replacement, and be as free as possible from noise and dust.*

To secure these important requisites, and, at the same time, to establish a completely stable foundation for pavements, is extremely difficult, if, indeed, it be not to a great degree, *impracticable.*

For, in consequence of the underground works of modern cities, such as sewers, gas pipes, and water conduits, to which access at all points must be allowed, for the purposes of repair, and attachment; the pavements of streets, must, if possible, combine with superficial goodness, such facilities of removal and replacement, as may enable the subterranean works to be reached at will, without serious impediment.

Unfortunately these conditions, which appear to exercise a paramount control over the streets of modern cities, absolutely preclude the employment of *concrete*, or *mortared masonry*, for the foundations of pavements; and also forbid the use of a very adhesive cement, between the paving stones themselves. Since all these methods, though beyond any question, of high importance to the formation of permanent pavements, *such, for instance, as the celebrated Roman ways,* appear to be inadmissible, from the fact, that they would make extremely difficult, if they did not entirely cut off, the necessary access to the underground works of the city.

It is these preliminary considerations which have prevailed with us, over a strong desire to suggest the use of *concrete foundations,* in which, upon well drained ground, we have entire confidence, and which would otherwise have been recommended by us.

A thorough system of under drainage, is of great importance to the stability and success of pavements, and the *sewage* of every great city ought, certainly, to be as carefully planned, and, eventually, almost as thoroughly carried out, as the system of the water conduits usually is.

The leading cities of Europe appear to be now sensible of the important influence exercised by a good sewage, upon the health and comfort of their inhabitants, and the stability of their pavements.

The intelligent gentlemen who testified before us, unanimously concurred in representing the superior durability of the pebble pavements, in those streets beneath which sewers run; and, in point of fact, that the surface water should be rapidly drained off in wet weather, and not be allowed to run long distances over the surface, and sink into, and saturate the undrained bed of the pavements, seems to be indispensable to their durability, and to the easy maintainance of a regular surface.

That Milan is one of the best, or, perhaps, the very best paved city in Europe, is as much owing to the fact, that every street has its sewer, with openings at short distances to receive the surface water, as to the system of paving employed, or to the mildness of the climate there.

An additional reason for the success of the street pavements in the Italian, Austrian, and other cities of Europe, may, however, be found in the fact, that, with the exception of London, Paris, and a few others, the travel upon the highways there, within the limits of the several towns, is far inferior in weight, and destructive action upon pavements, to that for which the highways of American cities must be planned, and to which they are continually exposed.

## SECTION II.

### *Asphaltic Pavement.*

We learn from the "*Papers on Practical Engineering,*" published for the use of the engineer officers of our army, under the direction of Col. J. G. Totten, Chief Engineer, and from other sources, that the bituminous mastic, commonly called the *Asphalte of Seyssel,* which appears to have acquired as high a reputation as any other composition of this nature, consists of a bituminous limestone, found in the Jura mountains, on the eastern frontier of France.

This stone is first roasted, then reduced to powder, and finally mixed up with about seven per cent. of mineral tar, or bitumen extracted from a mineral compound, called the *molasse,* which yields from fifteen to eighteen per cent. of mineral tar, when treated with boiling water.

"This tar, and the prepared calcareous asphaltum, are thrown together in the proportion of 93 per cent. of the latter, to 7 per cent. of the former, and thoroughly incorporated, by stirring the mixture in iron caldrons, while hot."

The success which attended the use of the *Asphalte of Seyssel,* and its kindred bituminous mastics, in the construction of footways, and other similar surfaces, to which they have, of late years been advantageously applied; naturally produced in the minds of many, a desire to have them used in the formation of highways for carriages; and accordingly, a pavement composed of fragments of quartz, cemented together by a very adhesive bituminous mastic, was laid in 1837, at the entrance of the "Place de la Concorde," in Paris, where it became immediately subjected to a prodigious travel, and for a short time it answered well, but ultimately proved to be a decided failure, and has since (we believe) been replaced by squared granite blocks.

M. Partiot, Chief Engineer, and Director General of Roads and Bridges, in France, has stated the cause of the failure of the bituminous pavement in the "Place de la Concorde" to be;

"That the contractor erroneously considered that his bituminous mastic was capable of resisting *the direct action* of the wheels, and horses' feet."

"This mastic which attaches itself very strongly to the stones, *should be used only for cementing them together, so as to form one solid block, but it should not be visible, the stone alone being seen on the surface.*"

"The stones of this pavement were not placed near enough together, and the intervals were filled with bituminous mastic, which is not capable of resisting the friction, so that the joints opened, and the surface of the pavement became rutty and uneven, *after only six months use.*"

We may here remark, in corroboration of the above, that the experience had in the application of the Asphalte of Seyssel, as it has been compounded, and used for floors and footways in Philadelphia, (which have been closely examined by the committee,) and the ease with which it may be indented, by moderate pressure upon small surfaces—such, for instance, as the feet of chairs—sufficiently indicates that this material, either alone, or combined with stones, may not be successfully applied to carriage ways, where its surface is exposed to the action of wheels, and to the feet of horses, as in a street, even if its great expense did not present an insuperable barrier to its adoption.

M. Partiot, the engineer above quoted, has expressed an opinion highly favorable to the use of bituminous mastics, *as a cement,* for uniting stones together in paving; but we need scarcely say, that if it is to be used in that manner alone, merely to form a bond of union, however good, between the stones of a paving, which are themselves entirely relied on to carry the passing weights, and to withstand the wear and tear of the travel, *the very name of bituminous, or asphaltic pavement becomes a misnomer;* since that term would certainly imply, that the asphaltic mastic was itself the predominating material, instead of being the mere cement *between* the predominating materials; in which mode alone, it has been justly said, that *asphalte* can successfully enter into the composition of a pavement, designed for the use of heavy carriages; and even in that mode, it would probably cement the stones together so strongly, as to render the access to the underground works of the city, difficult, troublesome, and, therefore, be *objectionable.*

The various *asphaltes,* though they have been made very much the objects of speculation abroad, by numerous joint stock companies, (some of them fraudulent) and by a great many patentees, and, consequently, have had their utility, and proper scope of application, greatly exaggerated by interested parties, are, nevertheless, very useful, though expensive, materials in construction.

Asphalte has been very successfully employed in military works, as a water-proof covering for the vaults of casemates, the floors of barracks, the roofs of military buildings, the footways of bridges, and other similar purposes, in Military Engineering.

It has also been used, to some extent, in the cavalry stables in France, but has not been applied in those of the Empire of Austria, though proposed for that purpose, and examined by the military engineers with that object, as we are informed, by an officer of that corps, temporarily resident here.

The footways of the Pont Royal, at Paris, formed of Asphalte, $\frac{52}{100}$ of an inch thick, required to be renewed within *five years,* though M. Partiot, in a careful calculation, had previously computed its period of duration at *seven years.*

Nevertheless, *asphalte* may be made exceedingly useful for footways, if, by a more sparing use of the mineral tar in its composition, it be made sufficiently stiff to resist the summer's sun, without injurious softening; it will, however, be much more expensive than the common "*herring-bone*" pavement of brick, so much employed in the American cities.

Finally, from the considerations above recited, *we conceive, that Asphalte, in any of the forms in which it has yet been used, cannot be recommended for the carriage ways of cities:* and, in support of this opinion, we may mention, in conclusion, that the *asphaltic pavements,* which, by way of trial, were laid some years since, in Oxford street, and in the Vauxhall road, in London, have entirely failed, or proved unsuccessful.

## SECTION III.

### *Wooden Pavement.*

This species of pavement, like that of asphalte, discussed in the preceding section, may be regarded as an innovation of the present century, since it is but recently that either have been introduced into our cities, as a part of the general system of paving.

Although a good deal of experience has now been had, in the use of *wooden paving,* both here, and elsewhere; there is yet a great diversity of opinion, as to the results, even amongst those who have for years daily witnessed the action of such pavements.

Discussions, warm, and even acrimonious, have been for some years going on in London, and are still in progress, both in fugitive pamphlets, and in scientific periodicals, relative to the merits and demerits of pavements of wood, of which large surfaces are now laid within the limits of that great metropolis.

Within the course of last year, forty thousand superficial yards, (or an extent nearly equal to thirty-six of our east and west squares,) were laid down by a single company—the Metropolitan—which has for some years been organized, with the view of introducing a particular form of wooden pavement into London; the same, in fact, as that laid in Walnut street, east of Third, and known as the plan of the Count De'Lisle.

We learn, on the one hand, that the authorities of Mary-le-bone Parish, in London, after long and patient trial, in Oxford, and other streets, and after much deliberation upon this subject, *have recently resolved to lay no more wooden pavements for three years:* and, on the other hand, we find it alleged, that this decision has not been well grounded upon the facts developed by the experience of London; and we further find, that some of the original opponents of wooden pavements, have since recanted their opposition.

With this maze of conflicting testimony before us, it is difficult to arrive at the true state of the case elsewhere; but it is quite certain, that wooden paving has not fulfilled the expectations of its projectors, though it was scarcely to have been anticipated, that it would have fully done so.

Wood paving, undoubtedly, possesses some peculiar advantages of a very decided character, amongst which, we may name the almost total extinction of noise—the reduction in the wear and tear of vehicles, arising from its regularity, and elasticity of surface—the ease of draught upon it—its cleanly condition—and the surprising manner in which it resists *mere wear.* On the other hand, besides its original expense, and want of durability when the wood is employed in its natural state, a very leading objection against the use of wooden pavements in cities, is to be found in their *slipperiness*, or the insecurity of the horses' foothold thereon, especially in wet weather.

So serious an objection is this, in the humid climate of London, that a leading scientific periodical, though, itself, favorable to wooden paving, describes the slipping of the horses upon such pavements there, after a shower, as being "*truly awful.*"

It seems that at such times it is difficult to stop an omnibus, for if the horses are suddenly pulled up, when in a trot, they slide forward, and often fall down, with injury to their harness and themselves.

This objection, though not so serious in our drier climate, applies, nevertheless, to a considerable extent, to the wooden pavements of Philadelphia, as many of our citizens have noticed.

Attempts to obviate this difficulty in Europe, have been productive of many patents, designing to provide a more secure foothold for the horses, by cutting the tops of the blocks, or their upper edges, so as to form a series of grooves, striating the surface of the wooden pavement in various directions transversely, or diagonally, according to a plan fixed by each patentee.

With regard to this remedy, it must be remarked, that if to furnish a stronger foothold, and avoid accidents to horses, it becomes necessary to cut the surface of a wooden pavement into grooves, besides the expense of that operation, two of the leading advantages of such paving, namely, ease of draught, and absence of noise, will be to a considerable extent impaired.

To maintain a regular and even surface with a wooden pavement, without which it could claim but little advantage, it seems to be necessary that it should be placed upon a very stable foundation; indeed, the Civil Engineer and Architect's Journal, in an able article advocating the cause of wooden pavements, admits, *that without a concrete foundation, to use wood for paving, would be a mere quackery, and a waste of money.*

Now, a concrete foundation, of proper solidity, presenting a barrier against the necessary access to the underground works of a city, conflicts with the maxim set out in our preliminary observations, and is, therefore, inadmissible on that ground, to say nothing of its cost, if so laid. With regard to the durability of wooden pavements, experience in Philadelphia has shown that *about three years* is the limit of duration for pavements of *hemlock;* but those of *yellow pine* and *white cedar,* promise to have a somewhat longer period.

We learn that in Russia the wooden pavements require renewal at intervals of about five years; and judging from sufficient experience of the decay of the sleepers of rail roads, which, like pavements, are in contact with the ground, (though upon the side, instead of end grain,) we cannot hope that pavements of *oak, or pine wood,* would last, upon an average, *more than six or seven years, at the furthest.*

It must also be observed, that the blocks of wooden paving, being placed in conjunction with each other sidewise, become peculiarly liable to that speedy rot, which seems inseparable from the lateral contact of wood; since it may be everywhere noticed in construction, and, particularly, in damp situations, that wherever timbers are in close contact, as at joints, and intersections, *there the progress of decay is invariably more rapid,* and this well known fact, may, in part, account for the speedy decay, evinced by the wooden pavements of this place.

From this it appears to follow as a necessary consequence, that to render wooden pavements satisfactory, the timber must be, if possible, preserved from decay to such an extent, as will essentially prolong its durability.

It is important, then, in this connexion, that we should now consider some of the means by which the durability of timber may be prolonged, though we do not intend to describe, or even to mention, all the antiseptic projects devised, or tried.

William Chapman, of Newcastle, England, a civil engineer of distinction and experience, published at London, in 1817, a treatise *"On the Preservation of Timber,"* in which he recorded numerous experiments made by himself, upon different woods impregnated with various substances; and he also embodied most of the practical knowledge then extant upon that subject.

He states that as long since as 1792, it was proposed to soak timber in copperas water, with a view to its preservation; it having often been observed, that many of the timbers used about copperas works, acquired surprising durability, when frequently exposed to the action of a solution of that substance.

In this work, Mr. Chapman announced, *that all the metallic salts were, more or less, antiseptic in their nature, and that when timber was impregnated with them, they coagulated the albumen of the wood, and had considerable effect in preserving the whole from decay.*

This principle so explicitly set forth—that of coagulating the albumen of the wood, by a metallic salt, and thus forming an insoluble and indestructible compound—is precisely the one which sundry modern projectors have seized upon with avidity, and sought to appropriate to their own use by letters patent; but few of which, however, could successfully stand the test of a legal discussion, if Chapman's treatise were given in evidence.

It further appears from Mr. Chapman's work, that boiling timber for three or four hours in a saturated solution of green vitriol, (sulphate of iron, or copperas,) has long been in use in Sweden; that it is found very advantageous there in preserving wood from decay; and that most of the timber used in that country for carriages, is thus prepared. We doubt, however, the utility of *boiling.*

Mr. Chapman tried impregnating timber with solutions of lime, and with coal tar oil, but neither of these proved to be satisfactory defences against decay; and he observes, relative to impregnation with salts of iron, "that the acetous fermentation should take place in the sap of timber, before it be macerated in a solution of copperas;" and observing this precaution, he projected the preparation of timber for the Royal Navy on a grand scale, by immersion in saturated solutions of sulphate of iron.

He also tried numerous experiments, by immersing pieces of wood in solutions of various metallic salts, such as nitrate of silver, corrosive sublimate, sulphate of copper, sulphate of iron, *and of the two latter salts combined.*

Mr. Chapman drew from these experiments, the inference, that in coagulating the albumen of wood, "the sulphates of copper and iron were both effective, and nitrate of silver, and corrosive sublimate, decidedly so;" and hence, he concludes, that thorough impregnation with any of these metallic salts, would prove decidedly antiseptic in its effects upon timber; though from motives of economy, he gave a preference to the use of a saturated solution of copperas.

The treatment above described, was designed by Mr. Chapman, to be preventive of decay; but he also used, with decided effect, as a remedy for dry rot already begun, a wash composed of *hot solutions* of sulphate of copper, of sulphate of iron, and of both these salts combined.

Sir Humphrey Davy, many years ago, proposed, as the result of some examination, a wash of corrosive sublimate, as a remedy for dry rot.

All the above preservatives and remedies were mentioned by Tredgold, in 1824, in his able and widely circulated treatise upon Carpentry, by which work, a notice of these antiseptics was extensively spread amongst artificers.

Thomas Wade, in a work published in 1815, mentions "that timber may be impregnated to advantage, with any of the following sulphates, viz., of *copper, zinc, or iron.*"

Robert McWilliam, Architect and Surveyor, in a treatise on the Dry Rot, published in 1818, says, "that of metallic salts I have frequently used with success, (for the prevention of dry rot) the sulphates of *copper*, *iron*, and *zinc;*" and he finally concludes, from all his experiments and observations, "*that any mode of impregnation by which timber can be made close, solid, and hard, in its whole bulk, or in its parts, so as to make it repel air and moisture, will secure its durability.*"

John Knowles, Secretary to the Surveyors of the English Navy, in a memoir published many years since, enumerated various proposed preservatives for timber, amongst which were the sulphates of copper, iron, and zinc, corrosive sublimate, eleven salts of earths and alkalies, and two acids.

McWilliam, in the treatise upon Dry Rot, above mentioned, says distinctly, "that *various preparations* of different metals have likewise been used with success, (to prevent decay in timber) particularly those of *iron, copper, and zinc.*

Upon the ample basis afforded them by the investigations and remarks of the writers above quoted, numerous individuals have grounded patents, and sought the aid of their respective governments, to enable them to monopolize the use of several preservatives for timber, which had long previously been used, or suggested, by others.

Amongst these patentees, the most prominent, are Bill, Kyan, and Burnet, in England; and Earle, in our own country.

Bill's patent is, (we believe,) for the impregnation of wood, with a preparation of coal tar.

Burnet's patent is for impregnating timber with the chloride of zinc, aided now by exhaustion, and subsequent pressure.

Although timbers prepared by both of these patent processes, have been subjected to some strong tests with favorable results; and though Burnet's process has recently found some strenuous advocates, and is now being introduced upon a large scale into the English dock-yards, neither of them have, as yet, been very extensively employed.

The antiseptic processes generally known as those of Kyan, in England, and of Earle, in this country, appear to have acquired the greatest notoriety, and have probably been more extensively used, than any of the others.

Kyan's process, which, under the name of *kyanizing*, has even added a word to our language, consists of steeping timber in a solution of the corrosive sublimate of mercury, formed in the proportion of 1 lb. of cor. sub. to 5 galls. of water, and continuing the immersion for a longer, or shorter period, according to the dimensions of the stick of timber immersed.

Mr. Kyan appears to have taken out *two patents,* the first under date of March 31st, 1832, (see London Rep. Pat. Invent. vol. xiv, p. 276,) was mainly, *for the preservation of wood,* by means of corrosive sublimate: the second under date of September 22nd, 1832, (see Newton's Journal of Arts, &c., vol. iii, conjd. series, p. 86; and Rep. Pat. Invent. vol. xvi, p. 9,) was confined in its application to such vegetable substances, or fabrics, as *paper, canvas, cloth, cordage, &c.*

We have before stated, that the application of corrosive sublimate of mercury, to vegetable substances, as an antiseptic, had been, many years before, prescribed by Chapman, and Davy, and had even been directly applied, by the former, with success, to the preservation of wood; still, as the efforts of these distinguished men had failed to attract the attention, or command the confidence of the public, to an extent sufficient to introduce this antiseptic into use amongst practicians; Mr. Kyan deserves credit just so far as he was the means of reproducing the invention, demonstrating its utility anew, and finally of introducing it into constructions at large, and rendering it generally available for practical purposes.

Nevertheless, that Mr. Kyan was enabled to obtain a patent for this process at all, is probably owing entirely to the English practice of granting letters patent for anything where the fees are paid, and leaving to the courts of law alone, the determination of the whole question of validity.

It is not probable that Kyan's process, as it is commonly called, can be sustained under the American general law of patents, since solutions of corrosive sublimate had been successfully used for the preservation of wood by Chapman, many years before; and in the language of our law, "*had been described in a printed publication, in a foreign country;*" that, therefore, the composition of matter employed by Mr. Kyan, had been, in the words of the same section, "*known, or used by others, before his discovery, or invention thereof;*" and, consequently, under the act of Congress, of July 4th, 1836, to which we now refer, a patent therefor, would seem to be untenable.*

We may here observe, that McWilliam has made the valuable observation, that the trees which are the most readily and advantageously impregnated with salts of iron, are those abounding with "the astringent principle (tannin and gallic acid):" whilst the "*coniferae,*" or trees of the pine family, being of a resinous, and not of an astringent nature, are but little affected by antiseptic preparations of iron.

This shows the propriety of confining the application of salts of iron mainly to such timber as *oak, elm, chesnut, ash, &c.;* and it may probably account for the very slight effect produced by the iron antiseptics upon resinous timber, as may be illustrated by the failure of Earle's process, as applied to hemlock pavement in this city.

In Earle's process for preserving timber from decay, for which letters patent of the United States, issued upon the 20th of September, 1838, the claim of the inventor is substantially as follows:

"For the boiling of timber in a solution of sulphates of iron and copper.

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* Nevertheless, Mr. Kyan, by special act of Congress, obtained a patent from the United States, under date of June 23rd, 1838, (see vol. xxiii. of this journal, p. 396, with the Editor's remarks.)

"I do not claim the saturating of timber by a solution of sulphates in water when applied cold, but confine my claim to boiling it in that solution from two to five, or six hours, or more."

The only novelty of this process of Earle's,* consists in *the boiling of the timber in* the particular solution named, that solution itself having been used in a cold state, for the same purpose, by Chapman, prior to 1817; and having also been long since applied *hot*, as a wash to preserve timber from decay, or to cure the dry rot.

The utility of boiling timber is very doubtful, and by McWilliam, in his treatise upon Dry Rot, it is pronounced *"to be positively injurious."*

It appears to us that the antiseptic properties of metallic salts, are nowise impaired by employing them in cold solutions, and that their activity cannot be much—if it be at all—augmented by the operation of *boiling*, which increases the trouble and expense, without, as far as we can perceive, attaining any valuable end, not equally attainable by immersion in saturated solutions at ordinary temperatures, particularly if exhaustion and pressure be used.

In addition to the above modes of augmenting the durability of timber, impregnation *with oil*, under great pressure, has been proposed by M. Breant, and some successful experiments with wood thus prepared, have been tried in the flooring of a bridge in France.

A powerful hydrostatic pressure, following a previous exhaustion, has been found useful in promoting a thorough impregnation of timber with metallic salts in solution; and impregnation with *kreosote* has also been proposed by M. Moll, a German mechanic.

Recently a cheaper metallic salt, and a different and superior mode of thoroughly impregnating the timber, has been proposed for use by M. Boucherie, and illustrated by many experiments of a conclusive nature.

A very interesting account of this process, translated from the French, by Professor John F. Frazer, may be found in the Journal of the Franklin Institute, for 1841.

M. Boucherie's method is to employ the impure pyrolignite of iron, as the antiseptic salt of impregnation, and to cause it to insinuate itself into all the pores of the wood, by means of the singular power of aspiration, developed by the sap of newly felled trees.

M. Boucherie's plan, in brief, is to fell the trees, and lop off all the branches except the top; then to connect the lower end of the trunk, by means of a water-tight bag, or any other suitable means, with a reservoir containing a saturated solution of the impure pyrolignite of iron; then the sap being gradually exhaled from the leaves remaining upon the upper branches, the ferruginous liquid is drawn up into the body of the tree, until, in a few days, it reaches the uttermost branches, and fills all the capillary tubes of the timber, coagulating, and solidifying in its progress, all the albumen of the wood, and greatly augmenting its durability, by rendering it, in the words of McWilliam, "*so close, solid, and hard, as to repel air and moisture.*"

Such is the force with which the sap is propelled forward through the pores of the body of a tree, in consequence of the exhalation from the top, when newly felled, that Dr. Hailes is his vegetable statistics, published about a century ago, mentions the case of a freshly cut vine branch, which being plunged at its lower end into mercury, drew that metal up into its tubes, to the height of *thirty-eight* inches; thus actually evincing a power superior to that with which the atmosphere acts against a vacuum!

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* *Boiling* wood in lime water, with the view of protecting it from decay, was also patented here, by Ringgold and Earle, August 6th, 1838.

From the satisfactory character of the numerous experiments adduced by M. Boucherie, there is strong reason to believe, that this process will be very efficacious, and as it is not expensive, it ought, certainly, to receive as full, fair, and speedy a trial in this country, as it has already had in France.

In point of fact from the results of experiments which have been made, we are led to infer, that a thorough impregnation with the salts of iron, may answer the end of considerably prolonging the durability of timber, and probably render unnecessary, the application of the more expensive salts of copper, or mercury, which seem to be more active antiseptics.

In addition to the above, we have gathered from the various English works on patents, and from the Civil Engineer and Architect's Journal, the following information, which may prove interesting in this connexion.

Murdock's Patent, May 2nd, 1791; proposed to preserve timber from decay, by a paint of sulphur, arsenic, and zinc.

Newmarch's Patent, February 25th, 1826; proposed to preserve timber from decay, by boiling it for three or four hours in a solution formed of the following materials, mixed in the proportions stated, viz., 3 oz. of sulphate, or acetate of copper, 3 oz. of white arsenic, and 1 gall. of linseed oil.

A mode of seasoning timber by placing it in an iron tank, resembling a steam boiler, and then exhausting the air from within, was patented by Langton, in 1825.

Mr. Carey, of the Royal Navy, in 1785, noticing the good effects proceeding from the plan then, as now, employed in America, of salting vessels whilst on the stocks; and, further, observing that whale ships were seldom attacked by dry rot, he conceived the idea of preserving vessels from decay, by filling all the spaces between the timbers, whilst under construction, with a mixture of oil and salt, thickened up to a proper consistency, by the addition of powdered charcoal, itself a powerful antiseptic.

With this compound Mr. Carey filled all the openings between the timbers of two vessels that he built in America in 1785, and in evidence of its efficacy, he states that in the year 1816, *or thirty years after*, he met with one of these, a brig of 200 tons burden, in the harbor of New York, which was still sound in nearly all its timbers, as he ascertained by boring many of them.

Sir William Burnet, in 1836, suggested, and was instrumental in testing on a large scale, a more effectual mode of causing antiseptic solutions to impregnate timber, than mere immersion was found to be;—this was by piling the wood within a suitable iron tank, then exhausting the tank to a partial vacuum, represented by a pressure of about 5 inches of mercury, then admitting the antiseptic solution; and, finally, subjecting the fluid to a pressure of about 100 lbs. to the inch above the atmosphere.

This method, with the chloride of zinc, employed as the antiseptic, has found some vigorous advocates, and is now beginning to be extensively applied abroad.

A leading objection urged against Kyan's process, is that the deutochloride of mercury employed, *does not* coagulate the albumen of the wood, or vegetable tissue, into an insoluble compound, since kyanized sails have had the corrosive sublimate so thoroughly washed out of them by the exposure of a single voyage, that an application of the usual chemical reagents failed to detect a trace of mercury.

Some wooden piles, also, which had been kyanized, and used in a sea work, were cut to pieces in a short time, by the "*teredo navalis*," or ship worm; thus rendering it probable, that in those cases, also, the corrosive sublimate had been washed out.

On the other hand it is certain that on some of the railways, kyanized sleepers have far outlasted similar sticks of unprepared timber, and are still sound.

Sir William Burnet's process of impregnating wood, &c., with a solution of the chloride of zinc, aided by exhaustion and pressure, is said to be free from the objection urged against that of Kyan; it seems to be superseding *kyanizing*, in the favor of the English Commissioners of the Admiralty, and nearly all the naval timber, sails, cordage, &c., to which antiseptics are there applied at present, are treated by Burnet's zinc antiseptic process, under the name of *burnetizing*.

One of the most recent antiseptic projects, is that of a Mr. Payne, who, calling both exhaustion and pressure to his aid, first impregnates timber with a solution of sulphate of iron, and afterwards with muriate of lime, which is said to attain the desideratum of forming an insoluble compound within the interior of the timber, and by its means, preserving the wood from decay.

We have entered thus at length into the subject of preserving timber from decay, because, without some efficacious means of augmenting its durability, the employment of wood as a material for paving, will, of necessity, be precluded by its expense, even if other objections should be overcome; and, because, with the use of proper antiseptics, we should still hope, that in particular situations, where absence of noise is paramount to all other considerations, wooden pavements may yet be used with advantage.

Locust and Red Cedar, which are justly esteemed as the two most durable woods accessible to us, have both been suggested as materials for paving streets; but it appears to us, that pavements of either of these, would probably be much too costly for ordinary use, even if the latter were sufficiently hard to withstand the action of the travel with success, or if, in both, the slipperiness of their surfaces could be obviated.

As an evidence of the costly character of the wooden pavements which have yet been laid in Philadelphia, we may refer to the following:

1. The hexagonal hemlock pavement, laid some years ago, in Chesnut street, between Fourth and Fifth, cost $2.50, per square yard; *and was decayed to such an extent, as to require renewal within three years.* This wooden pavement has recently been replaced by squared stone blocks, upon a gravel foundation, and laid upon the rectangular system.

2. The squared block wooden pavement, in Third street, north of Spruce, cost about $2.25 per square yard; and after *three and a half years use,* the hemlock portion of it is very much decayed, and needs renewal, while the heart yellow pine portion is still in apparent good order, though presenting strong symptoms of decay. This pavement was laid in September, 1839, and the hemlock portion, now patched in many places with pebble paving, will probably require removal in the course of the present year, 1843.

3. The wooden pavement of white cedar, formed of oblique prisms (doweled together) upon the Count De Lisle's plan, which was laid in Walnut street, east of Third, in 1840, cost $1.75, per square yard, and is still in good order.

4. The cubical hemlock pavement, in front of the State House, in Chesnut, between Fifth and Sixth streets, which was laid in July, 1839, cost about $2 per square yard; and after but four years use, had so extensively decayed, that it has this year (1843) been replaced by a cubical pavement of stone, laid upon the diagonal plan.

5. The squared hemlock block pavement, laid in Spruce street, between Tenth and Eleventh, cost about $2 per square yard of surface; it was laid in November, 1839, and though exposed to very little travel, it now exhibits unequivocal symptoms of speedy destruction.

In three of the above instances, viz., in Third street, north of Spruce, in Spruce, from Tenth to Eleventh, and in Walnut, east of Third, the expenses of the wooden pavements were partly borne by voluntary private subscription, as an inducement to the authorities of the city, to use wood in those streets.

The hemlock, which has been chiefly used in Philadelphia, for the wooden paving, is certainly the most unsuitable timber that could have been employed for such a purpose; nevertheless, its very rapid decay shows, but too clearly, the great liability of wood, in general, to rot under such circumstances; a consequence of which is, *that without the economical and successful application of antiseptics, to prolong its durability, wood must be given up as an economical pavement, unless future experience should indicate some wood, combining cheapness, with durability.*

The necessity of applying preservatives to the timber used in wooden paving, is strongly inculcated by the expensive experience of Philadelphia; and it is, consequently, a matter of regret, that such indifferent success has attended the application of Earle's process, to the first fifty feet of wooden pavement now laid in Sixth street, south of Chesnut; *many of the blocks of which are much decayed at this time,* though, by way of apology, it is asserted, that they were originally affected by rot, prior to being boiled in the solution of the sulphates of copper and iron, as prescribed in the patent of Dr. Earle.

It has been alleged with some truth, that wooden paving resists the wear and tear of the travel, in an equal degree with some stones that have been employed, but this assertion requires limitation; for although it is true to an unexpected extent, whilst the timber remains *perfectly sound*, yet the moment the coherence of its parts becomes impaired by the progress of decay, it yields to the travel with extreme rapidity, and quickly wears in holes: this may be witnessed in most of the older wooden pavements, where the middle of the carriage-way, being the most exposed to travel, has worn into deep unequal hollows, whilst next to the gutters, where they are less exposed to the action of the wheels of passing vehicles, the blocks retain their figure well, and though not less extensively decayed than the rest, they do not show it so soon.

Now, inasmuch as wooden pavements undoubtedly possess advantages which would render them useful at some points, and as experience abroad has not yet *definitively* decided upon their merits, we are not disposed, at this time, to condemn them entirely; but we would recommend to the Councils of Philadelphia, *to abide the result of the extensive practice of London, and other cities, where wooden pavements are now undergoing ample experiments*, and in the meanwhile—if they see fit—to lay, for trial, say *three* experimental intersections, in some well traveled street, with wooden pavements, as follows:

1. Of sound *Locust* timber.
2. Of sound and seasoned *White Oak*, prepared by immersion for one month, in a saturated solution of sulphate of iron.
3. Of *White Oak* prepared by Boucherie's process.

As no patent right would interfere, these experimental intersections, covering but little upwards of two hundred superficial yards in all, would cost but a small sum; and being laid in an economical manner, upon a pebble pavement foundation, (as specified in the Sixth Section following, for pavements of squared stone,) their construction would enable an estimate to be formed, of the probable expense of good wooden pavements upon larger areas; whilst, in a few years, they would clearly show what may be expected from pavements of wood, either of a quality well known for durability, or of other timber impregnated with antiseptics.

Finally, in consequence of the slippery nature of their surfaces, of their deficient durability when of ordinary timber, of their expense, immediate, or ultimate, and in view of the results of experience, as far as they have become known to us, we are reluctantly impelled to the conclusion, that though their use may be proper in some detached situations, *wooden pavements ought not, at this time, to be recommended as a part of a general system of paving, for the city of Philadelphia.*

In support of the above conclusion, it is proper to state, that since the preceding portion of this report was written, we have learned that the authorities of the city of New York, have determined to take up their decayed wooden pavements, and relay them with *stone;* whilst we perceive that some of the public prints of that place, in deploring the necessity of this renewal, declare that the wooden pavements there, have proved a signal failure.

We regret to learn that the experience of Boston, with regard to the deficient durability of pavements of wood, has been almost as decisive and unfavorable, as that of Philadelphia and New York; and it is also corroborative of the propriety of the opinion we have ventured to express *against the employment of wooden pavements here at the present time.*

## SECTION IV.

### *Stone Pavements.*

We now come to the consideration of stone pavements: traces of these, of the highest antiquity, are to be found in Egypt, but they are supposed to have been first employed as a regular system, by the Carthagenians; and after the subjugation of Carthage by the Romans, they were brought to the highest degree of perfection, by that conquering people, and pushed by them for military purposes, and with a characteristic energy, even into the remotest provinces of their mighty empire.

The Roman highways of dressed stone, usually polyangular, fitted with surprising neatness, and placed upon a solid foundation *of concrete, or masonry,* have formed the prototypes of modern constructions of this nature, and are scarcely to be surpassed in durability: some of them, in fact, being now in use, after having successfully withstood the travel and wear of fifteen centuries; though it must be remarked, that where such is the case, the travel is not to be compared in weight, or destructive action, with that which continually traverses the streets of modern cities.

The stone pavements in common use, may, with propriety, be considered under three separate heads, namely:

1. *Of pavements of dressed stone.*
2. *Of pebble pavements.*
3. *Of stone tramways combined with pebble pavements.*

All of these systems have some common points which require attention, and amongst these, is *the foundation,* which Mr. Richard Lovell Edgeworth, in his well known treatise upon Roads and Carriages, justly remarks, "is in all pavements the first thing to be attended to."

The common practice here is to make the foundation consist of about one foot in depth of gravel, thrown loosely into an excavation, and not otherwise consolidated, than by the travel of the carts, in which it is brought; this foundation, scarcely possessing sufficient strength for the most obscure and least traveled streets, is decidedly insufficient, when applied to the great thoroughfares.

Sir Henry Parnell, in his able treatise upon Roads, which has become a text book in these affairs, states that "the chief defects of all pavements arise from neglecting to give the stones a proper shape, and to construct a substantial foundation to support them."

The first question to be determined then, is, what foundation should be employed in pavements here?

We have already shown, in our preliminary observations, that *concrete*, and other similar foundations of great solidity, are inadmissible, for reasons that seem to be sufficient.

What then shall we employ for a foundation, which shall at once present sufficient solidity, and yet will not cut off the access to the underground works of the city?

It has been satisfactorily shown in the case of Fleet street, in London, referred to by Sir Henry Parnell, that a mere mass, or bed of broken stone, even if 12 or 18 inches in depth, when loosely thrown in, and leveled off, is totally insufficient to form a good foundation for a pavement; and that the only mode in which broken stone foundations can be made to succeed, is by forming the metal into a regular macadamized road, and consolidating it under the travel in *thin layers*, as is usual in such cases.

Sir Thomas Telford, the distinguished engineer, in his report upon the street pavements of the parish of St. George, says that, "as relates to the metropolis generally, I am persuaded that a bed of cleansed river ballast, *(gravel stones)* about six inches in thickness upon an average, will be found to answer the purpose (of a foundation)."

But in 1833, he remarked upon this same point, "that on reconsidering this subject, I am of opinion that this quantity of ballast will not make a sufficiently strong bottoming, and that nothing short of twelve inches of broken stones, put on in layers of four inches each, and then completely consolidated by carriages passing over them, will answer the purpose."

Now, the formation of a complete macadamized road, as a foundation for a street pavement, as recommended by Telford, (though, undoubtedly, sufficient for the purpose,) would be both inconvenient and expensive, while from its solidity, it would present a serious obstacle to any excavations which might become necessary in the street.

But there is another mode of forming a foundation for a pavement, which seems to satisfy the conditions we have set out; and with regard to a similar plan, recommended by Sir Henry Parnell, that author makes the following remarks:

"In those streets where there is a constant passing of carriages, both night and day, such as the Strand, Fleet street, Holborn, Cheapside, Piccadilly, and Oxford street, (in London) the foundation for the pavement, should be *a sub-pavement*, made of old paving stones, or any kind of coarse stone; and this should be laid upon a bed of broken stones. This mode of paving is in use in Paris. *In the autumn of* 1825, *for instance, the old pavement of the Rue Dauphine was taken up and relaid on a bed of gravel to form the foundation for the new pavement. This practice has proved completely successful.*"

This mode of laying new pavements upon foundations formed by a sub-pavement, made of the stones of the old one, is still practiced with success, in the streets of Paris.

In view of all the experience upon this point, the best mode of forming the foundation of a dressed stone pavement—suitable for the principal thoroughfares of a great city—which, after much consideration, has suggested itself to us, as giving sufficient stability, without involving too great an expense, or being attended with any serious inconvenience, *is to use a common pebble pavement for that purpose:* while, in other streets, where the travel is less, and where the pebbles themselves are retained as the paving, *the foundation of gravel may still be employed, if it be carefully consolidated in layers by rolling.*

The subject of *drainage* is intimately connected with that of foundations, and will now require our consideration.

A good drainage for the foundations of the pavements of a city, presents difficulties unknown in roadway engineering: for upon well constructed roads, mitre drains of rubble stone beneath the road surface, are made at proper intervals, to open into the side ditches, whence the water is readily drained away; and, by this means, the bed of the road can be maintained in a comparatively dry, and firm state: whilst the foundations of a street pavement, not readily admitting of this effectual lateral drainage, are much more difficult to be kept in good condition.

In many of the streets of cities, *sewers* have been omitted, in consequence of their expense, and hence much of the drainage *is merely superficial.*

It results from this, that the water which is shed from the houses, and from the sidewalks, being thrown into the depressed carriage ways of the streets, and combined with the downfall upon their surfaces, has often to run considerable distances along them, before it finds entrance to a sewer; this gives time for a great deal of the drainage water in its lengthened course, to soak down through the joints of the paving—thus saturating the foundations of the pavements, and, as a necessary consequence, rendering them weak, and liable to be broken up.

This is a great evil, and merits the closest attention of the authorities of a city, since a thorough system of underdrainage—whilst of high importance in a sanatory point of view—seems to be indispensable to the complete success, and stability of pavements.

Such, in every aspect, is the importance of a good sub-drainage, that we cannot refrain from recommending to the authorities of Philadelphia, *the immediate planning, and the gradual introduction of a complete system of sewage,* for it will not be until an underground drain exists in every leading street which has a retentive sub-soil, that the system of pavements can be rendered complete.

The mere underdrains of streets, or subordinate sewers, out of the natural lines of drainage, need not exceed two or three feet in diameter, the top being but three feet under the surface, having half brick openings occasionally, and being covered over with rubble stone, or brick rubbish, so as to admit of a free drainage, both direct and lateral.

Such underdrains may be easily located so as not to interfere with the gas, or water conduits, their expense would not be great, and if a comprehensive plan of sewage were but once adopted, and gradually put in execution, as the several streets of the city require repaving—

*with the view of finally forming an underground drain, or sewer, in every leading street, which is not on porous ground*—the annual outlay would be scarcely felt, whilst the improvement of our highways would soon be apparent; superior cleanliness would be insured, and the nuisances of transverse gutters, unstable pavements, and cellars wet by overflow, would quickly disappear.

Where sewers already exist under streets, a good underdrainage may be easily effected, by forming beneath the foundation of the pavement a longitudinal trench, some two or three feet square in section, directly above the sewer, filling the trench with rubble stone, (thus forming a blind drain) and causing it to communicate with proper apertures in the top of the sewer, by dry stone wells, at two or more points, in every square of its length.

Having thus considered the important collateral points of *foundation* and *drainage*, let us now proceed to a separate discussion of the several kinds of stone pavement.

1. *Of pavements of dressed stone.*—These pavements have for a long series of years, been employed for the principal thoroughfares in the leading cities of Europe; and in combination with pebble pavements, for the more subordinate streets, they have for centuries, formed the main part of the surfaces of city highways; although often rudely dressed, and badly laid, they have uniformly held the highest place in public estimation; and though of late years many projects have come up for superseding them by wood, or asphalte, yet since most of these attempts have proved abortive, it is probable that hereafter, as heretofore, uniform surfaces of dressed stone will be the most generally approved and used, in those great thoroughfares where smooth and durable pavements are an important desideratum.

When Mr. Telford was consulted in relation to the pavements of the parish of St. George, in London, he examined this subject with great care, and, with a commendable degree of caution, prior to forming his own opinion upon the matter in hand, he submitted sundry questions relating thereto, for the deliberation of the Civil Engineer's Institution, at repeated sittings, and the conclusions arrived at, by that very intelligent body, are thus stated:

"The result of these able, and very candid discussions, was *an unanimous resolution*, that whin, or granite pavement, of proper form and depth, laid on a sound bottom, *is preferable to any other mode for carriage ways* for the metropolis, and other large cities, in order to form a body of strength, adequate to bear the pressure and shocks of innumerable carriages, many of them conveying several tons."

Dressed stone pavements are, undoubtedly, very expensive in the first instance; and hence they ought only to be used in situations where diminished traction is desirable, or where the travel is so great as to render repairs of other pavements frequently necessary; in such cases—*as in the leading thoroughfares of a great city*—the original outlay becomes of less importance, when compared with the extreme durability, and other advantages of a suitable pavement of dressed stone.

Sir Henry Parnell mentions a pavement of this sort, which "had been laid down upwards of thirty years, and had cost very little in repairs." And the same author in 1833, mentions in relation to part of a great road leading into the city of London, which was paved with granite, under the direction of James Walker, C. E., President of the Institution of Civil Engineers, "that this paving has now been in use thirteen years, with almost the heaviest traffic out of London upon it, and, except the first year, when the contractor had to keep it up under his agreement, it has cost very little for repairs. It is now in excellent order, and the stones do not appear worn in the smallest degree."

The great durability, and the ease of traction, furnished by a dressed stone pavement, of suitably dimensioned stone, when it is properly laid, and properly founded, cannot, in point of fact, be disputed, and will justify its use, even as a matter of strict economy, in all streets that have to endure a crowded and heavy travel.

In the ordinary mode of paving with stone blocks, they are placed in courses perpendicular to the line of direction of the street, as has been done in this city, at the intersection of Sixth and Chesnut, and more recently in Chesnut, between Fourth and Fifth streets; but since upon this plan a number of joints lie parallel to the axis of the carriage-way, it has been found in practice, that the wheels of passing carriages, running in both directions along these joints, soon wear down, or round off, the arrises of the dressed stone blocks, so as gradually to form ruts, or holes between them, which in time render such pavements rough and uneven, and finally cause them to break up.

M. Le Large, a French writer in 1717, recognized this defect, and in a memoir upon the different modes of paving roads with squared stone, which may be found in the third volume of the "*Machines et Inventions approuvèes par L'Academie Royale des Sciences*," he suggested *a diagonal disposition* of the courses of stone, as a remedy therefor; and furnished two plans, or sketches, showing how the stones of a pavement might be so arranged in courses forming respectively, angles of 45°, and of 26½°, with the axis of the street.

The views of M. Le Large upon this point, were adopted and enforced by Mr. Edgeworth, in 1813, in his able essay on *Roads, &c.*, which was published at that time; but, notwithstanding the authority of this writer, and the approbation of the French Academy, *the diagonal system* of paving has not been as generally adopted as it deserves to be, though, in all probability, it will ultimately supersede the *rectangular mode.*

In the sixth volume of the Technical Repository, H. W. Revely, Civil Engineer, mentions that dressed stone pavements upon the diagonal system of large stone, *furrowed* transversely, were successfully employed long prior to 1824, "in the streets of Florence, Pisa, Leghorn, and other cities of Tuscany;" and he recommended similar pavements, laid in courses at an angle of 45° with the axis of the street, and forming salient angles in plan, at the middle of the carriage-way, as being suitable, in a high degree, for the pavements of the city of London.

We learn from Capt. Charles Mœring, an intelligent engineer officer in the Austrian service, now on a visit here, that in the great city of Vienna, the leading thoroughfares are now uniformly paved *in the diagonal manner,* which pavements succeed admirably, and which after sufficient experience under the heavy travel of that important place, have proved themselves to be so decidedly superior to the ancient pavements upon the rectangular system, that these latter are now relaid in the diagonal form, as fast as renewals become necessary.

If we leave the results of practice for a moment, and turn to abstract considerations, we shall find that they would lead us to form a favorable opinion of the diagonal mode of paving, for it is evident, that in a good dressed stone pavement with close joints, the most favorable direction in which a carriage wheel can act upon a joint, is perpendicular thereto, while the worst, is when the wheel runs along the length of the joint; hence in a pavement where part of the joints are parallel, and part of them perpendicular to the line of travel, unequal wear must inevitably result, and a roughness of surface ensue.

At the intersections of streets, where the travel upon both carriage ways, traverses the parallel joints, the wheels running in one street, will wear one set of joints, whilst in the line of the other carriage way, the rest of the joints will be injured, and, consequently, a pavement so situated, must wear rounding, and become irregular, in the course of time.

From the nature of the case, we should, therefore, conclude, that those pavements would wear the smoothest, and last the longest, which should be laid in such manner, *that carriages passing in both directions upon their surfaces, would cross all the joints of the paving at equal angles.*

This condition will be answered upon *the diagonal system,* even at the intersections of perpendicular streets, by causing the courses of paving to form angles of 45° with the axis of the carriage way.

Another strong argument in favor of a diagonal disposition of paving stone, may be found in the recent practice of distinguished engineers, upon many of the English railways.

The heavy stone blocks, square in plan, which carry the chairs of the edge rails, were formerly disposed with their sides parallel, and perpendicular to the track, occupying the same position as in a rectangular system of pavement; but now upon the London and Birmingham, and other great railways, the squared stone blocks are all placed *so that the line of the rails traverses a diagonal,* or are, in fact, disposed in relation to the travel, precisely as they would be in the diagonal system of paving: this change in the position of railway foundations, has resulted from a just conviction upon the part of the engineers, that a stone block disposed diagonally to the travel over it, *presents superior stability, both longitudinally, and laterally, since the lines of resistance in such case, become longer in both of these directions,* and this argument we need scarcely say applies with equal force to a stone block in a paved street.

A strong argument in favor of hexagonal blocks for paving streets, may be drawn from the foregoing considerations; since, if a hexagon be placed horizontally in a pavement with two of its sides perpendicular to the axis of the street, the lines of travel will intersect the other four sides at angles of 30° in both directions; so that, in fact, they will cross two of the sides of the hexagon, in the most favorable direction possible, whilst all the other sides by their diagonal disposition, become more exempt from the injurious action of wheels along the joints, than would be the case with blocks of any other geometrical figure, *if set in regular transverse courses,* and would only be surpassed in this respect, by masses rectangular in plan, *and set diagonally at angles of forty-five degrees with the line of the street.*

We conclude then, *that a diagonal disposition is the best for dressed paving stone,* and having discussed the method of arrangement, we are now to consider the proper size for the stone blocks of a dressed pavement, and upon this point we find that considerable variation exists, both in successful practice, and in competent opinions.

Thus, in Naples, where stone pavements are laid upon the diagonal system, the blocks are closely jointed, are two feet square horizontally, and present a superficial area of four square feet each: in Pisa, Florence, and Leghorn, the stone blocks are also large, but in all these cases they become, by use, so dangerously smooth, as to require numerous furrows to be cut transversely to the line of travel, in order to secure a proper foothold for the passing horses; and in our own country, in the city of Boston, where a portion of Tremont street, in front of the Tremont house, is paved with granite blocks of eighteen inches square, showing two and a quarter superficial feet each, transverse furrows have also been found necessary.

These transverse furrows are laborious in execution, and also objectionable, on account of their roughness, and the noise they produce under vehicles—*fortunately they are not indispensable*—since in most of the cities of Europe, the same end has been answered by using smaller stone, and it is for this reason that in those cities, generally, the stone blocks are dressed into cubes of about two-thirds of a foot side, and showing, when set, only about one-half of a superficial foot, exposed to the travel.

Bryan Donkin, a Civil Engineer, in some interesting papers upon paving, written many years ago, proposed that dressed stone for the London pavements should be 5 inches broad, 7 to 8 inches long, and 10 to 13 inches in depth, vertically.

Sir Thomas Telford proposed for the pavements of the parish of St. George, in London, that the dimensions of the dressed paving stone should be as follows:

For streets of the—

| | | | | | |
|---|---|---|---|---|---|
| 1st. class, | 10 ins. deep; | 11 ins. to | 13 ins. long; and | 6 ins. to | 7½ ins. broad. |
| 2nd. | “ 9 “ | 9 “ | 12 “ | 5 “ | 7 “ |
| 3rd. | “ 7 or 8 “ | 7 “ | 11 “ | 4½ “ | 6 “ |

Sir Henry Parnell, like Telford, divided streets into three classes, proportionate to the travel over them; and he recommended the dimensions of the dressed stone to be as follows:

For streets of the—

1st. class, 10 ins. deep; 10 ins. to 15 long; and 6 ins. to 8 ins. broad.
2nd. " 8 " 8 " 12 " " 5 " 7 "
3rd. " 6 " 6 " 10 " " 4 " 6 "

The French engineers have been in the habit of forming their dressed paving—*like dice*—into rigid cubes of about 8 inches side; their example has been pretty generally followed upon the continent of Europe, and we may mention, that cubes of about this size, are employed in those streets of Vienna, which have been so successfully paved in the diagonal manner.

Although the best authorities differ in some degree, as to the most suitable dimensions of paving stone in a horizontal direction, *they all agree that a rigid uniformity of depth is indispensable;* and we may here remark, that in consequence of this maxim amongst others, having been overlooked, or neglected, in laying recently the dressed stone pavement in this city, in Chesnut street, between Fourth and Fifth, that piece of paving is neither a good specimen of dressed stone pavements, nor will its durability be such as might have been expected, if proper care in its construction, foundation, and materials, had been duly observed.

To satisfy the necessary conditions, it would seem that the showing surface of dressed stone paving, ought to bear to the horizontal dimensions of the hoofs of horses, a relation sufficiently close to secure a foothold, and avoid slipping; whilst, at the same time, the block should have sufficient bearing surface, should be incapable of tilting under a passing wheel, and should have an extent of base equal to that of the surface exposed to the travel.

The size established by the practice of continental Europe, may, perhaps, be regarded as a close approximation to the best dimensions possible, though slight departures from it horizontally, keeping the depth uniform, and maintaining regular courses, would not impair the character of the pavement, whilst the allowance of some little latitude in the superficial dimensions, would certainly be promotive of economy in getting out, and preparing the stone blocks.

It has sometimes been proposed to form the stone blocks into oblique prisms, as well as into some other shapes, but upon this point we have no hesitation in declaring the opinion, *that all the stone ought to be rectangular prisms,* as we can perceive no advantage in the figures of the other solids suggested, which would be at all commensurate with the trouble and expense of forming them.

In laying a dressed stone pavement, it is important that the joints should not be more open than those of masonry usually are, or, in other words, the stone blocks should not be allowed to set a wider joint, than from three-sixteenths to one quarter of an inch.

The advantage of a closely jointed pavement, over one that is not so, is well shown by the first fifty feet of the stone pavement recently laid in Chesnut street, east of Fifth, which portion certainly exhibits a decided superiority over the remaining pavement in that square, though its joints are wider than we should prescribe.

Whilst the noise of vehicles passing upon a well dressed, and closely jointed pavement, would be trifling, and the ease of traction great, no serious apprehensions need be entertained, that pavements with joints of the size we recommend, will be too smooth, as we have no reason to believe that horses would often slip upon their surfaces, if stone of a suitable quality be used.

Sir Henry Parnell observes upon this point, "that it is supposed by some persons, that if the streets were paved in the way proposed, (that is to say with *dressed stone)* their surface would be too smooth for horses to go safely over them; but this supposition is not well founded, except when that kind of stone is used which becomes polished by wear."

"Scotch granite, and some other kinds of stone, do not become polished, and, therefore, pavements made with them, will never have so smooth a surface as to be unfit for horses. A horse properly shod will seldom slip on a pavement, or fall, unless when thrown down by being turned too short, or other careless management."

In support of these observations, it may be remarked, that on the well dressed pavements of Vienna, and other European cities, a dangerous slipping of horses occurs so rarely, as not to form a valid practical objection; though it must be admitted, that in the nature of things, a certain degree of slipperiness, is inseparable from the smoothness of all good pavements.

Finally, with regard to pavements of dressed stone, we have, in substance, concluded—that they ought to be laid upon a foundation formed by another pavement, as is the custom in Paris—that the stone blocks should be disposed diagonally at angles of 45° with the axis of the street—that these blocks should approximate closely to a cube of eight inches side, or be parallelopipeds nearly cubical—that none of the joints between the blocks, when set, should be allowed to exceed three-sixteenths, or a quarter of an inch in width—and that the depths of all the blocks should be strictly uniform.

(To be continued.)

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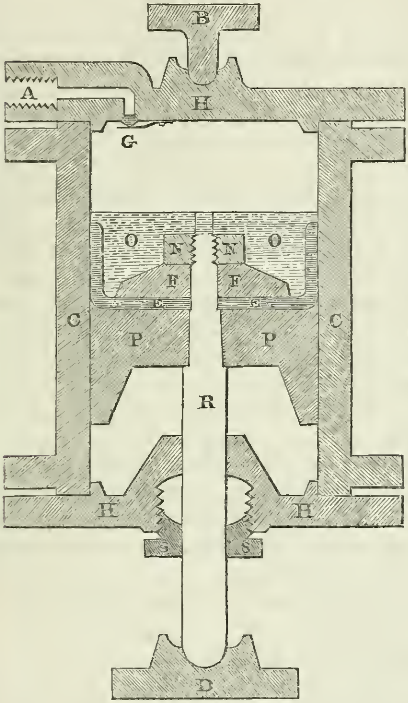
## *Report on Bisssell's Pneumatic Car or Carriage Spring.*

The Committee on Science and the Arts constituted by the Franklin Institute of the State of Pennsylvania, to whom was referred, for examination, the Pneumatic Car or Carriage Spring, invented by Levi Bissell, of Newark, New Jersey, REPORT:

That this spring is constructed with a cylinder closed at both ends, and charged with condensed air, which is acted upon by a piston. The cylinder is charged by a force-pump through a small opening in the upper head, which is closed by a valve opening inwards. The piston is of solid cast-iron, with a stem, or rod, passing through a stuffing-box, in the lower head, into a seat, or socket, on which the spring acts. The packing of the piston consists of a leather cup of the exact diameter of the cylinder, and of about two inches in depth, resting on its upper surface, and secured to it by a circular cast-iron plate, and a nut screwed on the upper end of the piston rod. This cup is partly filled with ground white lead, upon which is placed a quantity of oil—say two inches in depth—to make the piston air-tight. The weight supported by the spring rests on the centre of the upper head of the cylinder. The spring submitted for examination, was one of four designed to support an eight-wheeled passenger car, of about ten tons weight, including its load. The cylinder was of cast-iron, six inches calibre, ten inches long, and three-fourths of an inch in thickness.



A, opening to attach air-pumps.
B, post sustaining load.
C, cylinder.
D, seat for piston-rod.
E, leather cup-packing.
F, cast-iron follower.
G, valve and valve-spring.
H, H, cylinder heads.
N, nut to secure packing.
O, oil and white lead.
P, piston.
R, piston-rod.
S, stuffing-box.

Springs of this description, made by Mr. Bissell, have been in use on the railroad cars running between Philadelphia and New York, for more than one year, and, the committee understand, have given entire satisfaction to the officers of the railroad company, and the traveling public. The difficulty originally and generally anticipated in their use, viz.,—the escape of the air from the cylinder, under a pressure of from two to four hundred pounds per inch, has not been realized—on the contrary, some of those in daily use have retained the air for upwards of five months, and remain in perfect order.

The arrangement of this spring is, undoubtedly, ingenious, but the committee feel bound to state, that it cannot be regarded as a novel invention. It is almost identically the same as the *Pneumatic Railroad Carriage Spring, Railway Buffer, and Elastic Drag,* invented by Mr. Burstall, and patented in 1839;—a description and drawing of which can be found in the London Mechanic's Magazine, vol. xxxi., p. 423. Mr. Burstall employed a cylinder, inclosing condensed air in a flexible sack, which was acted on by a piston in the same manner as that of Mr. Bissell. Mr. Stephenson, the celebrated English engineer, also employed cylinders with solid pistons, which acted against the water and steam, on his locomotive steam engine boilers *as springs*, as far back as 1814; descriptions and drawings of which can be seen in almost every work published upon railroads since that date. Mr. Robert Bowman, of Scotland, also invented a similar contrivance, for the purpose of stopping, or checking, chain cables of vessels, in 1825. It consisted of two cylinders fixed parallel to each other on the deck of the vessel, that were charged with condensed air by a force-pump, and were acted upon as a spring by pistons;—a description and drawing of which can be found in Newton's Journal of Arts and Sciences, vol. ii., p. 179. Mr. Robert Mallet, of England, also patented a similar contrivance in 1836, which he describes in vol. xxxvi. of the London Mechanics Magazine, p. 212. In his description of his improvement, he speaks of having used *a leather cupped packing, containing oil, or water, to make it air tight.* Mr. Mallet preferred water to oil, because it would not penetrate the leather under pressure, as readily as oil. Mr. Bissell prevents it, by a mixture of white lead with the oil. See also a description of Church's Air Spring, in Newton's (London) Journal of Arts and Sciences, vol. ii., conjoined series, p. 97 and 98, which is [identical] with Mr. Bissell's spring in almost all its details.

The committee award much credit to Mr. Bissell, for the energy and patience with which he has introduced, and put in use in this country, a valuable, though, not a novel, improvement. Mr. Bissel obtained a patent for his springs, which is dated the 11th of October, 1841.

By order of the Committee,

*October 13th*, 1842. William Hamilton, Actuary.

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## Civil Engineering.

### *Mr. Vignoles' Lectures on Civil Engineering, at the London University College.*

[Continued from Page 80.]

#### LECTURE XIII.

In continuation of the observations on *Railway Estimates*, which had been commenced in the last lecture, Mr. Vignoles observed that, having therein gone fully into the items of *construction* of railways, he had only glanced at the very necessary provision to be made for the efficient *working* of them—viz., the *Station and Carrying-establishment*, upon which he would say a few more words, for it was mostly under this head that the chief causes—or, rather, the chief excuses—for extra expenditure, or excess of estimates, had arisen. Properly speaking, this item, so costly, and yet so indispensable, should be taken as falling on a railway company, not as proprietors of the road, but as carriers—the distinction being, that if the railway was let on lease, as canals have been, or if every body could carry on the railways, as they do on the canals—if, in short, public safety and public convenience, and generally necessary arrangements, did not make it imperative, or, at least, highly desirable, that the railway companies should be carriers (of passengers, at all events,) the expense of stations, and carrying establishment would not fall on them, though they must still be incurred by some parties, before the railway can be brought into profitable operation; nevertheless, the public, who are to use, and be benefited by the road, having, after all, to pay in one shape or another, are greatly interested in a proper expenditure, any excess of which is sure to be felt in increased charges, or in diminished accommodation, until the grievous expenditure of a rival line is introduced. In analyzing the cost of *Stations*, it is obvious that the land always forms a prominent item, for, being near towns and populous places, it is to be bought by the yard, and not by the acre—building land, villa land, &c. &c., instead of mere fields. Hence, it will not be surprising, if it is found that the cost of the land, for the stations only, on many of the great lines, has amounted to as much as one-third of the whole cost of land for the railway. The *buildings* erected at stations may be divided into three classes—those for the accommodation of the passenger traffic—those for the goods, minerals, &c.—and those for the repair and maintenance of the engines, carriages, &c. At principal towns, therefore, large and distinct establishments must be erected; and, on long lines, a principal central depot for the engines, is often required in addition. At the minor and road stations, the whole may be grouped together under one roof. In no department of expenditure, have so many differences, and so much useless extravagance in construction and arrangement, been displayed, as in the buildings at stations; and hundreds of thousands of pounds have been absolutely thrown away, from want of sufficient forethought and consideration, and by erecting enormous masses of buildings, either at the wrong places, or in an injudicious manner. It was better to wait until the character of the traffic was ascertained, before making such expensive permanent establishments, and then increase the accommodation by degrees. As an example of a moderate expenditure under this head, Mr. Vignoles mentioned some particular instances, and went somewhat into detail. At the terminus of a railway in a manufacturing town, with 80,000 inhabitants, there had been an expenditure of £9,500, for the passenger buildings, sheds, &c. &c.; £5,500, for goods' warehouses; about £2,000, for the mineral traffic; and about £3,000, for fixtures, turnplates, &c.—say, in all, about £20,000, exclusive of the land, which had amounted to a very large sum, upwards of £13,000, including a good deal of spare space, existing buildings, &c. &c. At a smaller town on the line, but with some extent of goods traffic, the cost for passenger buildings, sheds, &c., was £2,500; for merchandize accommodation, £3,500; turnplates, fixtures, tools, &c. &c., £1,000; land about £3,000. On the same railway, the cost of six or seven various minor road stations, including water tanks, coke, and engine sheds, tools, &c., was £3,500; land about £1,500; sundries on the whole line about £1,000—being a gross expenditure of £50,000 on station, land, and buildings, for a line of about twenty-two miles, which is at the rate of £2,273 per mile; and the corresponding carrying establishment of engines, tenders, &c. (for passenger traffic only), was about £19,000; for passenger carriages of three classes, horse-boxes, trucks, &c. &c., about £13,000, (the wagons for merchandize, coal, &c., as well as the engines, &c., being provided by carriers on the line, who provided their own carrying stock); and the necessary buildings for repair, and maintenance of engines, carriages, &c., with tools, fixtures, &c. &c., about £12,000—making a gross cost of £44,000, or £2,000 per mile. The whole of this concern having been arranged with the strictest regard to economy, may be taken as a fair average, and it will be safe to say, that £4,000 per mile, for an effective carrying establishment, with the necessary stations, is a moderate sum. For lines of less traffic, if of considerable extent—as, for instance, say for some of the long lines from the present railway termini in the north of England, to either of the principal towns in Scotland, a smaller amount might be sufficient; but Mr. Vignoles considered that it would be unwise to estimate a smaller expenditure than that of £3,000 per mile, for *Stations and Carrying-establishment*, on a line to be worked by locomotive engines, and it would be much safer to take £4,000; on either of these sums, £1,500 per mile for the locomotive stock and buildings must always be estimated, and about £500 per mile for the carriage department—leaving from £1,000 to £2,000 per mile for the stations, according to the extent of accommodation; keeping the instances of the extraordinary outlay on some of the principal railway lines as examples to be avoided, and not to be imitated, or referred to, as necessary.

Under the last head of *Management*, came all the various and miscellaneous items of expenditure, between the first concoction of the project, to the closing of the capital account. The preliminary expenses of examining the ground, leveling, surveying, maps, &c., and all the formalities in the engineer's department, to enable application to be made to Parliament; the ascertainment of the traffic, revenue, traveling, and other expenses of various kinds, &c. &c., generally undertaken by the secretary; the valuation of land, &c., by the surveyor; the collection of the names of the owners and occupiers, notices to them, applications for their assents, &c., and the management of the bill throughout all its stages, falling to the charge of the solicitor. All these must be incurred before a spade was put into the ground, and had heretofore varied from £500 to £1000 per mile, according to the facilities afforded, the opposition encountered, the length of the line, &c. In future estimates, it was to be hoped this item might fairly be put, as not exceeding the smaller of these sums. Then came the setting out of the line, the detailed levels and surveys, and all the office work of the engineer, until the works are put into the hands of the contractor. The minute valuations of the property to be taken, and the juries, references, conveyancing, stamps, and all the various legal steps, until the company are put into full possession. Then the office establishment for regulating all the financial and ministerial affairs, and the temporary arrangements, police, lawsuits, and legal and illegal charges of all kinds, taxes and rates, interest and commission to agents and brokers, traveling expenses, salaries, and a great variety of disbursements of a miscellaneous kind, which, in the aggregate, amount to a large sum. The whole of the outlay thus coming under the head of *Management*, has varied from 5 to 10 per cent. on the gross cost of the railways hitherto executed, according to their extent, and the amount of capital embarked, and especially according to the degree of vigilance exercised to keep down expenses. which depends chiefly on the director, or secretary, or under whatever name the acting manager of the company may superintend. Judging from the examples past, and the deep impression which has been made on the public mind, of the necessity of economy in every department, Mr. Vignoles thought 5 per cent. might be estimated hereafter, unless the lines were very short, and the capital small.

In recapitulation, the Professor observed, that the young engineer should always keep in view, for his estimates, the preceding great divisions of the cost—viz., *land*, including the damages, and fencing —*earthwork*—*works of art* (bridging and masonry, &c.)—*upper works* (the permanent railway proper)—*stations and carrying establishment*—*management*—and having, in his first estimates, allowed amply for each of those items under their several heads, he should add at least 10 per cent. for unforeseen contingencies. Some of the preceding items would be common to almost all railways, and others, of course, would vary greatly, according to local circumstances, chiefly regulated by the amount of earthwork; for, as that is heavy, so the works of art become costly, since the works of art are merely to restore the existing communications of the country, and the natural, or articial, water-courses, and drainage to their state before disturbed, or as near as may be, and that to an extent in exact proportion to the civilization, and improvement of the country, to enforce all which stringent clauses are inserted in the Acts of Parliament, and plenty of persons are always on the watch to enforce them. Mr. Vignoles observed, that the land, leveling of the ground, and restoring of communications, might, on the average, including contingencies, extra land, &c., be taken as forming about 50 per cent. on the total outlay of railways hitherto executed. But, referring to the items the Professor had gone over in detail in previous lectures, it appeared that, when proper economy and circumspection were used, the necessary cost of the railway proper—that is, the necessary quantity of land for the road only, a good substantial set of upper works for a double way, and a complete and effective carrying establishment—might, and had been, obtained for £10,000 per mile. All beyond is expenditure to obtain gradients, more, or less, perfect, and Mr. Vignoles thought that the great error all engineers had hitherto committed, the cardinal mistake —of which he himself was far from guiltless—was, seeking to make railways, intended, as they were, chiefly for passengers, *too perfect*— that is, of cutting down hills, and filling up valleys to too great an extent, on the erroneous supposition that the engines were always to carry *maximum* loads, which was very seldom the case, and never would be so on lines at a distance from the metropolis, particularly such as the lines into Scotland, previously mentioned. In short, the Professor insisted that the engineer should, in such instances, and for the cross railways, which he yet hoped might be introduced, make the gradients and curves much less theoretically perfect; and that the amount of expenditure, beyond the above stated necessary one of £10,000 per mile, should be reduced to the very *minimum;* and he considered that henceforth an average of £15,000, or £16,000 per mile, and a *maximum* of £20,000, or, in very extraordinary cases, indeed, of £25,000, should be looked to for the construction of double lines of railway in any country, but that in most cases, of light traffic, and consequent adaptation of gradients, for single lines, a sum of from £7000 to £12,000 per mile. would be the limit of total expenditure. Mr. Vignoles concluded by observing, that the preceding abstracts were deduced from very detailed accounts, which had been arranged on a uniform system, and kept from the very commencement of each undertaking, so as to be available at any time during the progress of the works, to show the exact state of the expenditure; and had been finally worked out to the nearest thousand pounds, as above. And the Professor expressed his great hope and expectation that this example would be followed, and that similar accounts would shortly be forthcoming, of the corresponding items of cost on all the principal railways in this and in other countries, more especially where complaints of improper excess of expenditure over estimates (well or ill-founded) had been charged, for the publication of such accounts—and the more in detail the better—would be the most complete defence of the directors, and the most satisfactory explanation from the engineer, and alike valuable, as statistical information to the country—as salutary guidance to the capitalist and speculator—and as valuable information and warning to the old, as well as to the young practitioner.

The preceding is a very brief outline of this interesting lecture, and the following, we believe, is a correct abstract of the cost of the two railways quoted by Mr. Vignoles.

### COMPARATIVE ABSTRACT

Of the Cost of two Principal Lines of Railway, under the general heads of Expenditure, as deduced from the very latest accounts of Actual Expenditure, brought out to the nearest round numbers:

MIDLAND COUNTIES RAILWAY.
[57¾ MILES.]

| Heads of Expenditure. | — — — | Pr. ct. whole cost, | C't. pr. Mile £ | Total Cost. £ |
|---|---|---|---|---|
| Railway land, and damages, | (790 acres) | 12 | 3463 | 200,000 |
| Fencing, gates, roads, &c., | | 3½ | 1004 | 58,000 |
| Earth work, | (5,700,000 cubic yards) | 18½ | 5455 | 315,000 |
| Works of art, of all kinds, | [tons] | 15 | 4364 | 252,000 |
| Iron rails and chairs, | Upper Works £215,000—(17,670) | 23 | 6822 | 394,000 |
| All other materials, and labor, | 179,000 | | | |
| Station land, and damages, | Stations and carrying establishment. £ 51,000 | 21 | 6147 | 355,000 |
| Buildings, fittings-up, &c., | 168,000 | | | |
| Engine, &c. stock, | 75,000 | | | |
| Carriage, &c. stock, | 61,000 | | | |
| Management, law, interest, &c. | | 7 | 2182 | 126,000 |
| Totals, | — — — | 100 | 29,437 | 1,700,000 |

NORTH UNION RAILWAY.
[25 MILES.]

| Heads of Expenditure. | — — — | Pr. ct. whole cost | C't. pr. Mile. £ | Total Cost. £ |
|---|---|---|---|---|
| Railway land, and damages, | (320 acres) | 8 | 2000 | 50,000 |
| Fencing, gates, roads, &c., | | 3½ | 800 | 20,000 |
| Earth work, | (2,900,000 cubic yards) | 20½ | 5000 | 125,000 |
| Works of art, of all kinds, | | 20½ | 5000 | 125,000 |
| Iron rails and chairs, | Upper works £68,000 (6885 tons.) | 21 | 5200 | 130,000 |
| All other materials, and labor, | 62,000 | | | |
| Station land, and damages, | Stations and carrying establishment. £18,000 | 16½ | 4000 | 100,000 |
| Buildings, fittings-up, &c., | 48,000 | | | |
| Engine, &c. stock, | 20,000 | | | |
| Carriage, &c. stock, | 14,000 | | | |
| Management, law, interest,&c. | | 10 | 2400 | 60,000 |
| Totals, | — — — | 100 | 24,400 | 610,000 |

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

## *American Steam Excavator of Otis, or the Yankee Geologist.*

Having availed himself of a recent invitation from Messrs. Eastwick & Harrison, Engineers and Machinists of this place, to view *three* well constructed steam excavators, which these gentlemen have just completed for the Emperor of Russia, and are about to ship for that country, to be there employed upon the extensive railways about to be commenced; the writer collected a little information relative to them, which may, possibly, interest some of the readers of this journal.

These steam excavators, as devised by the late ingenious Mr. Otis, are really high efforts of inventive talent, and will do credit to American ingenuity wherever they are seen and used.

But *seven* of these machines have yet been built, the whole of which, excepting the first, having been made by Messrs. Eastwick & Harrison; the first was partially completed at various workshops, under the direction of the inventor, Mr. Otis, in person; but finding some diffiulty in organizing and fitting up so complicated a machine, by this method of proceding, he fortunately placed it in the hands of Messrs. Eastwick & Harrison, who skilfully perfected the details, and gave such good proportions to the several parts, that all the machines constructed, including the experimental one, have proved, in practice, to be completely successful, though it has been deemed advisable to give augmented strength to those recently built.

The present price of these machines in Philadelphia, is $6,500, but in consequence of the patterns being now on hand, and of the complete system, introduced by these excellent mechanics, into the manufacture of this new machine, it seems probable that Messrs. Eastwick & Harrison may, hereafter, be able to furnish them even at lower rates.

The high pressure steam engine, which operates each of the excavators viewed by the writer, has a single cylinder, of 9 inches in diameter, and 1 foot stroke, the speed of the piston being usually about 200 feet per minute, when the pressure on the safety-valve is 100 lbs. per square inch; and, consequently, in the ordinary mode of computing small high pressure engines, it will realize *about fifteen horses' power.*

From the large amount of work which has already been done by some of these machines, in an active service of several years, there seems to be but little doubt, that one of them, in a common working day, *can dig and load from* 800 *to* 1200 *cubic yards of average earth.*

The scoop will contain about a cubic yard of earth measured in the cut, and a common day's work is 1000 full dips of the scoop, but 1200, or 1300, have frequently been made; we may, therefore, from our present information, set down as a certain average work, 1000 *cubic yards excavated, and loaded upon cars per day.*

It will be borne in mind, that the *"yankee geologist"* merely does the digging and loading, or the getting and filling, *the transportation, dumping, trimming, &c.*, remaining the same as though the cars had been loaded by the labor of men, in the usual manner.

In heavy excavations of common earth, where a large number of men have been employed, the writer has often observed, that the work of hands rarely averaged more than 12½ cubic yards, loaded into a cart per day, per man, the earth being previously *loosened* by the pick, or plough.

Now, taking the wages of men at *one dollar* per day, including all charges, and putting the *loosening* at the moderate estimate of one cent per cubic yard, the actual cost of digging and loading, in an average case of heavy earthwork, would be *about nine cents per cubic yard.*

We will now, from the best information before us, frame an estimate of the probable cost of excavating and loading ordinary earth in heavy cuts, by the aid of the *"yankee geologist."*

*Probable Annual Charges.*

| | |
|---|---|
| Interest on cost at 6 per cent. on $6,500, | $ 390 |
| Renewals, wear and tear, say 25 per cent., | 1,625 |
| One cord of wood per day, at $4, for 300 days, | 1,200 |
| Oil and packing, $1.50 per day × 300 days, | 450 |
| Two machine tenders, at $1.50 per day, for 300 days, | 900 |
| Eight car tenders, at $1 per day, for 300 days, | 2,400 |
| One overseer, for 300 days, at $2 per day, | 600 |
| Total expenses per annum, say, | $ 7,565 |

Now, in 300 working days, this machine would, from the data given, excavate and fill into cars, about 300,000 yards; and hence, it would appear, that where it is able to work 300 days in a year, this machine would dig and load ordinary earth, at the extraordinary low rate of two and a half cents—or, allowing for contingencies, say *three cents per cubic yard;* which is only about one-third of what it would cost by manual labor.

Such is the surprising result, to which the writer has been led by the information laid before him, by Messrs. Eastwick & Harrison, and which, if it be even approximated to, in the general continuous working of these steam excavators, *will, inevitably, enable them to banish manual labor from the digging and loading, in all heavy earthworks.* M.

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FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

## *Mr. Mallett's Close Breast for an Overshot Water-Wheel, not New.*

In the July number of the Journal of the Franklin Institute, the writer has observed an abstract of some experiments made by Mr. Mallett, to prove that an advantage of from "8 *to* 11 *per cent.*" may be obtained by the use of a close breast to confine the water upon the lower quadrant of an overshot water-wheel.

These experiments seem to have been announced to the Institution of Civil Engineers, by Mr. Mallett, and discussed by that intelligent body, as though the application of a close breast, in the manner referred to—or, at the least, the valuation of its advantages—had been both new and original with Mr. Mallett; and though we will not pretend to say that the latter was not the case, we cannot repress a feeling of surprise, that such a well read man should have overlooked the fact, that the Franklin Institute, upon a much superior scale to his, had, long since, made with full sized water-wheels, all the experiments necessary to settle conclusively, every point relative to "*the coefficient of laboring force in overshot water-wheels, &c.*," which he has attempted to illustrate, by his little tin models of 25 and 33 inches in diameter.

It was for the very purpose of obviating the just objections urged against the results obtained by Smeaton, Bossut, Banks, and others, from *little models* of water-wheels, that the extensive experiments of the Franklin Institute were undertaken.

In the face of these, and of that able series of trials made by Morin, on water-wheels actually driving heavy works in France, are we now to return again to the imperfect conclusions derived from insignificant models? We anticipate the answer of well trained mechanics every where to be NO!

It would have been singular, indeed, if an experiment so obvious, as that of applying a close breast to the lower acting quadrant of an overshot water-wheel, should have escaped the attention of the committee of the Franklin Institute; and, accordingly, we find their conclusions upon this point, recorded in vol. i., 3rd. series, of this journal, p. 368, where they clearly show, with regard to the "*use of a close breast with an overshot water-wheel*," that the ratio of effect to power, "appears to be in favor of the use of the breast, in the proportion of .751 to .702, or of 1.07 to 1.00, under the average of heads from 0.25 to 3.75 feet, and of head and fall from 10.5 to 14.0 feet."

In conclusion, we recommend these prior experiments to Mr. Mallett's consideration, as furnishing a much safer basis for practical operations, than can possibly be the case with his own. M.

*On the causes of the unexpected breakage of the Journals of Railway Axles; and on the mean of preventing such accidents by observing the Law of Continuity in their construction.* By William John Macquorn Rankine, Assoc. Inst. C. E.

The paper commences by stating that the unexpected fracture of originally good axles, after running for several years, without any appearance of unsoundness, must be caused by a gradual deterioration in the course of working; that with respect to the nature, and cause of this deterioration, nothing but hypotheses have hitherto been given; the most accepted reason being, that the fibrous texture of malleable iron assumes gradually a crystallized structure, which being weaker in a longitudinal direction, gives way under a shock, that the same iron, when in its fibrous state, would have sustained without injury.

The author contends that it is difficult to prove that an axle which, when broken, shall be found of a crystalized texture, may not have been so originally at the point of fracture, although at other parts the texture may have been fibrous.

He then proceeds to show that a gradual deterioration takes place in axles without their losing their fibrous texture, and that it does not arise from the cause to which it is usually attributed.

From among a large collection of faggoted axles which had broken after running between two and four years, five specimens were selected, of which drawings are given, representing the exact appearance of the metal at the point of fracture, which in each case occurred at the re-entering angle, where the journal joined the body. The fractures appear to have commenced with a smooth, regularly formed, minute fissure, extending all around the neck of the journal, and penetrating, on an average, to a depth of half an inch. They would appear to have gradually penetrated from the surface towards the centre, in such a manner that the broken end of the journal was convex, and necessarily the body of the axle was concave, until the thickness of sound iron in the centre became insufficient to support the shocks to which it was exposed.

In all the specimens, the iron remained fibrous; proving that no material change had taken place in its structure.

The author then proceeds to argue, that the breaking of these axles was owing to a tendency of the abrupt change in thickness, where the journal met the shoulder, to increase the effect of shocks at that point; that owing to the method of manufacture, the fibres did not follow the surface of the shoulder, but that they penetrated straight into the body of the axle; that the power of a fibre to resist a shock being in the compound ratio of its strength and extensibility, that portion of it which is within the mass of the body of the axle, will have less elasticity than that in the journal, and it is probable that the fibres give way at the shoulder, on account of their elastic play being suddenly arrested at that point. This, he contends, would account for the direction of the fissure being inward towards the body of the axle, so that the surface of the fracture was always convex in that direction.

It is, therefore, proposed in manufacturing axles, to form the journals with a large curve in the shoulder, before going to the lathe, so that the fibre shall be continuous throughout; the increased action at the shoulder, would thus be made efficient in adding strength to the fibres without impeding their elasticity. Several axles having one end manufactured in this manner, and the other by the ordinary method, were broken: the former resisted from five to eight blows of a hammer, while the latter were invariably broken by one blow.

The vibratory action to which axles are subjected is then considered, and it is contended, that at the place where there is an abrupt change in the extent of the oscillations of the molecules of the iron, these molecules must necessarily be more easily torn asunder; and that in the improved form of journals, as the power of resisting shocks is increased by the continuity of the superficial fibres, so is the destructive action of the vibratory movement prevented by the continuity of form.

The paper is illustrated by five drawings, showing the section of the journals of broken axles, and their appearance at the moment of fracture.

Mr. York agreed with Mr. Rankine in several points, and stated, that since the last meeting, he had made a series of experiments, which confirmed his opinion relative to the vibration in solid railway axles being arrested, when the wheels were keyed on tight. In all such cases, where the vibration was checked, fracture would, he contended, be more likely to ensue, but with hollow axles, there was very little difference of sound when struck, and no diminution of strength, after keying on the wheels; this he attributed to the regular distribution of the molecules in the metal of the hollow cylinder.

Mr. Parkes coincided with Mr. York's opinion, and he believed that hollow axles would eventually supersede solid ones, particularly if they had sufficient rigidity for resisting flexure. Their faculty of transmitting vibration more readily was in their favor; it was well understood, that in pieces of ordnance, and musket-barrels, great regularity of proportion in the metal was requisite, in order to insure the equal transmission of the vibration, caused by the sudden expansion of the metal at the moment of the explosion, and unless the vibration was regular, the barrel would burst, or the ball would not be correctly delivered.

Mr. Greener, of Newcastle, among other experiments, turned the outside of a musket-barrel to a correct taper, and fixed tight upon it at given intervals, several rings of lead, 2 inches in thickness; on firing a charge of 4 drachms of powder, he found that all the rings were loosened, and had all expanded regularly in their diameter.

It was a well known fact, that cannon seldom, or never, burst from continuous firing; such accidents, unless they arose from peculiar circumstances, generally occurred in consequence either of inequality in the nature of the metal, or irregularity in its distribution; to the latter cause must be attributed the bursting of the "Mortier monstre," before Antwerp, and of a large gun which was proved at Deal, some time since; this latter gun burst at the third discharge, after delivering the ball better than on either of the previous discharges; it was evident that the fracture did not occur under the explosion of the powder, but on the re-entering of the air into the mouth of the gun after the discharge, and also because the thickness of metal was not well proportioned, whereby the vibration was unduly checked, the cohesion of the molecules of the metal was destroyed, and the gun fell into several pieces, without any of them being projected, as they would have been by the usual effect of an explosive force.

The most practical millwrights were well aware of the superiority of hollow shafts, and they were frequently used, as they were more easily kept cool than solid ones, especially at high velocities, when shafts were peculiarly liable to injury from percussive force, or from a series of recurring vibrations.

Lond. Mechanics' Mag.

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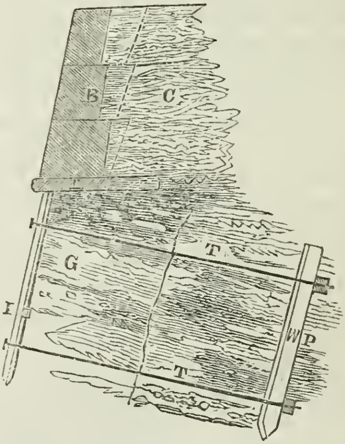
## *Greenwich Pier.*



We abstained last month from giving any account of the failure of this pier, which took place on 16th of May last, as we had not then an opportunity of personally inspecting it, or of ascertaining its construction; we have since been favored by our valuable correspondent, O. T., with the following observations, and sketch of the pier. He observes, "the failure of Greenwich pier is not a matter of surprise to parties who understand the practical construction of such works. The immediate cause of the failure was dredging in front of the piles, after the contractor had left the works, and the arrangement of the piles being faulty, as regards construction; the upper part is composed of brickwork in cement B, 18 feet high, and 14 inches thick at top, capped with granite 1 foot thick, backed with concrete, C, and standing upon a foundation of Yorkshire stone landings, L, laid on a small quantity of concrete, with a substratum of foul gravel, G. The landing, in front, rests on a row of cast iron piles, I, P, 25 feet long, and 5 feet apart, grooved to admit between them three cast iron plates, each 6 feet in height, these iron piles were fastened by four, or two, pair of wrought iron land ties, T, 2 inches square, to wooden piles, W, P, 18 feet long, and 12 inches square, driven in land at a distance of 25½ ft. from the front, and 5 ft. apart." The high water mark is about 4 feet from the top, and low water mark 22 feet below, or about 7 feet below the stone landing. From inquiry, we rather suspect the lower ties, as shown in the sketch, were not fixed, nor do we see how they could be, as they are shown considerably below low water mark. The superincumbent weight of the brickwork appears to have forced out the upper part of the iron piles to a considerable distance, and caused the brickwork above to slip down, and force out the iron plate; but, it is very difficult to say whether this is the real cause of the failure, for, until the ruins are cleared away, nothing positive can be stated.

Civ. Eng. & Arch. Journ.

## *Railway Axles.*

A paper by Captain Handcock was read May 16th, 1843, describing a railway axle invented by him, which had been used for nine months on the Southampton Railway. The alterations consisted in making the journals of a conical form at the shoulder end, and at the outer end, a similar conical collar slides upon the journal, and can be forced forward by a screw collar at the extremity; the brasses are also conical at the entrances, following the parallel form of the journal, and meet in the centre within half an inch; they can revolve in the bored cast iron boxes when the friction upon the axle becomes excessive. It has been found that this form prevents the usual oscillation of the carriages, because, if the brasses wear, the conical collar is screwed up, and the lateral motion ceases; the wear and tear is diminished, and the saving of oil is very great: it was stated that one pint of oil had sufficed to lubricate all the axle-bearings of a six-wheeled engine, and a four-wheeled tender whilst running 924 miles; and that there was not any tendency to heat.—*Trans. Civ. Eng.*

Lond. Athenæum.

## *Unburnt Bricks from the Pyramids of Daskmoor, Egypt.*

From the description by Mr. Perring, who brought them to England, it appeared that they were made from the alluvial soil of the Valley of the Nile, mixed up with chopped straw; that they were made with cavities in the sides like the modern bricks, and that the interior of the Pyramids was formed of *arches*, the bricks composing them, being either packed behind with pieces of flat pottery, or cut away to radiate equally from the centre. There existed at Thebes some extensive ranges of arches, of about twelve feet span, the bricks of which they were built bearing the name of Sesostris, and, consequently, they must have stood uninjured upwards of 3180 years: the arches were turned in concentric half-brick rings. Ibid.

## *Captain Norton's Lotus Floating Breakwater.*

On a lake or pond where the lotus grows, Captain Norton had observed, that when there was a strong breeze, and waves on one side, on the other the water was comparatively smooth, resulting from the wind having no hold on the broad expanse of lotus leaves. He had also observed, after a storm at sea, the solid timbers of a wrecked vessel splintered in pieces by being driven against the shore, while a wicker basket escaped uninjured. These two results suggested the idea of constructing a floating breakwater of oziers, according to the singularly ingenious model in the Polytechnic Institution, the expense of which would be trifling compared with others.

Polytechnic Journal.

## Architecture.

*The Principles of Landscape-Gardening and of Landscape-Architecture applied to the laying out of Public Cemeteries and the Improvement of Churchyards; including Observations on the Working and General Management of Cemeteries and Burial-Grounds.* By J. C. Loudon, F. L. S., H. S., &c.

(Continued from page 98.)

### II. THE LAYING OUT, BUILDING, AND PLANTING OF CEMETERIES.

The *buildings* required in cemeteries may next occupy our attention. A chapel, or chapels, are generally required, because some persons prefer the burial service read under cover, or this may be rendered necessary by the state of the weather. The size of a chapel, therefore, should be such as to afford seats for the ordinary number of attendants at a funeral, with an open area in the centre, of sufficient diameter to hold two or more coffins on biers; and, as it is a general custom in Christendom to carry a corpse with the feet before, the body being brought in, and set down on the bier in that position, is, after the service is over, taken up by men and turned completely round, so that the feet may be in advance before it is taken out of the chapel. In addition, therefore, to the space necessary for holding the bier and the coffin, there must be room for turning the latter completely round, either while on the bier, which has long handles for that purpose, or on men's shoulders. A circle 10 or 12 feet in diameter, or a square that would contain such a circle, will afford ample space for these purposes, and the remainder of the chapel may be occupied with the pulpit, desk, seats, &c.

In the chapels of some of the new London cemeteries, instead of biers for the coffins, there is a table, the top of which has one or two spaces, each of the width of a coffin, filled in with rollers, and the entire top of the table turns on a pivot. The coffin, or coffins, when brought in, are put on the table, by sliding them on the rollers; and, after the service has been performed, the table is turned round on its pivot, when the coffins being thus placed in the right position for going out, are carried away by the bearers. The rollers facilitate the sliding on, and drawing off, of the coffins, and the turning of the table, by means of the pivot, saves the most difficult and awkward portion of the labor performed by the bearers, who, when not much accustomed to it, are apt to stumble, and create alarm in the mourners lest the coffin should fall. When a bier-table of this kind is used, the area left for it need not exceed 8 ft. in diameter, which will thus save 4 ft. in the entire length, and the same in the breadth, of the chapel.

A very convenient apparatus of this kind has been put up at the Kensal Green Cemetery. In the body of the chapel is a bier, in the form of an altar, about 8 ft. long, 4 ft. broad, and 4 ft. high, hung round with black velvet. The upper surface of this altar-like structure consists of a top for holding one or two coffins; and, to facilitate the putting on and taking off of these, this plate, or top, is furnished with rollers. After the desk service has been read, the top containing the coffin, or coffins, can be turned slowly round by machinery, operated on by a small movable winch handle on one side, which is done after the service has been read, when the interment is to take place in the open ground, or in the catacombs at a distance from the chapel; but, when the coffin is to be removed to the vaults under the chapel, there is machinery below, worked by a man there, on a signal being given, by ringing a small bell, by which the entire bier, and the coffin, or coffins, which may be on it, are slowly lowered into a central area in the vault beneath. The mourners having descended by a staircase much too small for a chapel so magnificent in other respects, the coffins are carried from this area to the vaults, which radiate from it in four directions, and occupy nearly an acre of ground. The machinery by which the bier is lowered, consists of two vertical male screws, worked by two female screws, or nuts, which are moved by means of two beveled wheels set in motion by a man turning a windlass handle. This machine, while it lowers the bier through the floor, moves at the same time two horizontal shutters, which gradually close the opening in the floor, as the coffin descends from the view of the spectators in the chapel; while, by the time they have arrived in the area below, the bier is already at the bottom, with the coffin on it, ready to be removed to the vault. The great advantage of using a screw movement for the descent of the bier, is, that the motion can never be otherwise than slow and solemn, and that it cannot run down in case of the handle being set at liberty. This admirable contrivance was invented and executed by Mr. Smith, Engineer, Princes Street, Leicester Square, the patentee of an excellent window shutter, and of several other inventions noticed in our *Encyclop. of Cott. Architecture.* The cost was about 400*l.* In the Norwood Cemetery the same object is effected by means of Bramah's hydraulic press, which raises and lowers the bier with the slightest possible noise, and with a degree of steadiness which cannot be equalled by any other machine. The cost is about 200*l.* There is one drawback, however, to this machine, which is, that during very severe frosts the water is liable to freeze; but this may be guarded against by shutting all the outside doors of the vaults, and by the use of stoves. In ordinary winters, however, the latter are unnecessary. This machine was put up by Messrs. Bramah, Prestage, and Ball.

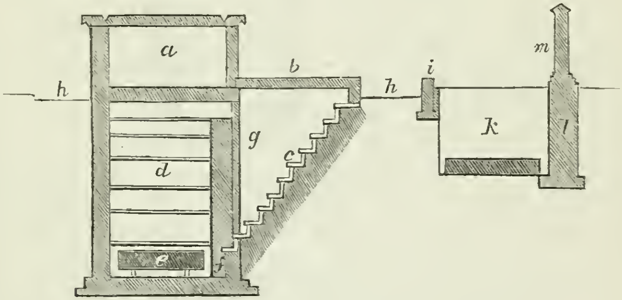
The number of sittings need seldom exceed fifty, at least in the neighborhood of London, as it rarely happens that more than a fourth of that number attend a funeral. Whatever be the architectural style of the chapel, it ought to contain a bell, the ringing of which, when the hearse is approaching from the entrance gate to the chapel, may be considered as a part of the burial service. The bell ought to be placed in a bell turret, rising from one of the gables, so as to become a conspicuous feature, and distinguish the chapel from a cottage, or barn, in the same manner as the chimney tops of a dwelling are characteristic of a human habitation.

The *entrance lodge* to a cemetery ought to comprise a room to serve as an office to contain the cemetry books, or, at least, the order book and register, and the map book, where, from the system of squares being employed, such a book is rendered necessary. In small cemeteries, and in common churchyards, where the sexton is also the clerk and registrar, all the books, and other documents, will be kept in a strong closet in this room; but, in large cemeteries, managed by a court of directors, the books are kept by a clerk in the cemetery office, in the town, or district, to which it belongs, and only an order book, and the register and map book, or duplicates of them, are kept in the lodge.

*Vaults* are commonly made under churches, or chapels, but in the large cemeteries they are also made in the open ground, in deep excavations descended to by stairs, and ranged on each side of a passage, or passages, which are lighted through iron gratings on the surface. One of the best examples, on a small and economical scale, is the public vault in the Abney Park Cemetery. The most classical situations for vaults, is in the face of a steep rocky bank, where they require no drainage, and can be entered without descending more than a few steps; such as occurs in the St. James' Cemetery, Liverpool; the Sheffield Cemetery; and the Cathedral, or Necropolis, Cemetery of Glasgow. Catacombs above ground, like those in the London and Westminster Cemetery, like some private tombs in the Kensal Green Cemetery, and like those in the new burying-ground attached to the old church at Brighton, are, in our opinion, in bad taste; since the general idea of burial, no matter by what mode, implies the descent of the body below the surface of the ground. Private vaults for the use of a single family, are commonly made of the width of two or three coffins, and of such a depth as to hold several placed one over the other, commonly with iron bars, or plates of stone between, so that no coffin may have more to bear than its own weight, and the air may be allowed to surround them, to prevent them from rotting. Sometimes each coffin is placed in a separate cell, and closed up with masonry.

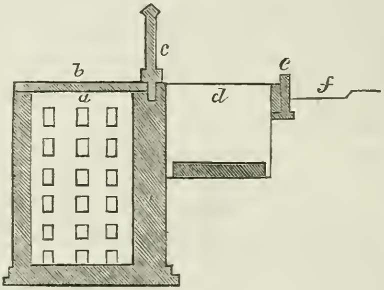
*Catacombs.*—Sometimes the vault is divided into cells like bins in a wine-cellar, by vertical divisions of brick, or stone; and these cells are called catacombs, though the term is frequently applied to a vault, or crypt, not sub-divided into cells. Each cell, when the coffin is inserted, is hermetically sealed, by building it up with brickwork, or inserting a tablet of stone, or marble, inscribed with the name, age, &c., of the deceased. In the new London cemeteries, the cells, or catacombs, are frequently only closed with an open iron grating, the end of the coffin being fully exposed to view. In some cases the cells are literally shelves, and the entire side of the coffin is exposed, as in the West London Cemetery. Both of these modes are attended with gerat danger to the living; whether by the bursting of the lead coffins from the expansion of the gas in the bodies within them, or from its escape through crevices in the lead coffin left accidentally, or through holes made on purpose by the undertaker under the brass plate, as already mentioned. When a private vault is formed on even ground in an open cemetery, steps are made for descending to it; and these steps are commonly covered by a flat stone, level with, or slightly above the surface; or in some cases, as where the steps are under a walk, or path, the stone is concealed under this. Over the vault is placed a monument of some kind, most commonly what is called a square tomb, as in fig 3.; in which *a* is the tomb, or superstructure; *b*, the cover to the steps; *c*, the steps; *d*, the catacombs, or cell; *e*, a coffin placed in the lowest catacomb, and sealed up at *f*; *g*, a door of slate, flag-stone, or iron; and *n*, the grass alleys. In this figure is also shown a common grave, in which *i*, is the foot-stone; *k*, the grave, containing a coffin at bottom; *l*, the basement wall to the head-stone; and *m*, the head-stone.

Fig. 3.



A *brick grave* is a substitute for a vault, and differs only from an ordinary grave in having the sides and ends of brickwork, or masonry, and in being covered with a large flat stone, technically, a ledger-stone. These graves are generally purchased and built by heads of families. Sometimes they are of the width of two coffins, but generally of one; and they vary in depth from 10 ft. to 20 ft., or upwards. When an interment takes place, the stone is loosened by levers, and removed by means of rollers; and, the coffin being let down as in common graves, the ledger-stone is replaced and cemented. The side walls are built concave next the grave, in order that they may act as arches against the exterior soil; and, in some cases, they are furnished with ledges which project 2 or 3 inches from each side, for retaining a flag-stone, or slate, between each coffin. When this flag-stone is securely cemented, the coffin below may be considered as hermetically sealed, though it is not very likely that this will be done so completely, as to prevent the ascent of the mephitic gas. In other brick graves no ledges are projected, but one coffin is prevented from resting on another, by inserting two bars of iron in the side walls, so as to support each coffin. When the coffins reach within 3 or 4 feet of the surface, the ledger is put on for the last time; and a putrid mass of, perhaps, 15 ft. in depth, is left to generate poisonous air, will escape, probably for years, through such crevices as may be left, or as may occur from the action of the weather, or other causes, between the ledger and the side walls on which it rests. The proper mode would be to fill in the uppermost 6 or 8 feet of the grave with earth. The names of the interred are inscribed on the ledger, in the order of their interment; or a monument of some kind is erected on it, of such dimensions, and in such a position, that it can be removed in one piece with the ledger, without being loosened, or otherwise disturbed. In the Highgate Cemetery there are ledger-stones weighing, with their monuments, eight, or ten tons, which are removed all in one piece every time an interment takes place. The more common mode, however, is to place a head-stone as a monument, as shown in the section, fig. 4. In this section, *a* is the side wall of the grave, here shown with openings to permit the lateral diffusion of moisture and mephitic vapour; *b* is the ledger, or covering stone; and *c*, the headstone. At one end is a common grave *(d)* with its footstone *(e)*; and one of the two double green alleys, which form boundaries to the raised panel of graves, is shown at *f*.

Fig. 4.



Brick graves are also used as earth graves, and filled to the surface with soil every time after an interment has taken place. The openings for reinterments should, as we have already mentioned, never be sunk to a greater depth than within 6 ft. of the last deposited coffin; in which case no very great disturbance, or danger, from putrescence would take place, more especially in clayey, or loamy, soil, and when it is made a rule to ram the soil hard with a cast iron rammer, to the height of at least 6 ft. above every coffin as it is deposited.* When the last deposited coffin is within 6 ft. of the surface, the grave should be finally closed. Graves of this kind are not necessarily covered with a ledger-stone; they may be finished with a raised mound of earth, like a common earth grave, or the side and end walls may be finished with curb-stones a foot above the surface, and the interior left level, or planted with flowers. After the last interment, a cypress, or other tree, or a strong-growing herbaceous plant, might be planted in the centre. The walls of graves of this sort should be built with numerous openings, as in fig. 4, to permit the lateral diffusion of the products of decomposition, and of the natural moisture of the soil.

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* Family graves, in some of the new cemeteries, are made from 12 ft. to 30 ft. in depth. We lately saw one in the Norwood Cemetery, which had been originally 20 ft. deep, and had one coffin deposited in it, after which it was filled in to the surface with soil. It was, at the time we saw it, being opened to the depth of between 18 ft. and 19 ft., and the smell proceeding from the earth brought up, was, to us, intolerable. This, and numerous other cases which we have witnessed, or which have come to our knowledge altogether, independently of the Parliamentary *Report on the Health of Towns*, for 1842, or Mr. Walker's *Gatherings from Graveyards*, have strongly impressed us with the necessity of a law to limit the proximity of one coffin to another in graves in which more than one interment is made, unless, as before observed, the coffins are put in on the same day.

*Earth graves* are of two kinds: *private graves*, in which only one body is deposited, with, or without a monument; and *common graves*, in which several bodies are deposited, of poor persons, or paupers, for whom no monument is ever put up, except a mound covered with turf, but which ought always to be marked with a stone number for reference, and to prevent all risk of their being opened again at any future period.

To be Continued.

## Mechanics and Chemistry.

### *On certain improvements on Photographic Processes described in a former Communication, and on the Parathermic Rays of the Solar Spectrum.* By Sir J. F. W. Herschel, Bart., K. H. F.R.S., &c.; *in a letter addressed to S. Hunter Christie, Esq., Sec. R. S.*

*Dear Sir*,—I beg leave herewith to submit for your inspection, and that of the Royal Society, a series of photographic impressions, illustrative of the chrysotype, cyanotype, and other processes, an account of which is given in the postscript to my last paper on that subject, which has, by permission of the president and council, been appended to the original in its printed form subsequently to the termination of the session. In the interval which has since elapsed, besides the discovery of other photographic novelties (which may form the subject of future communications), I have been enabled materially to improve some of the processes there described; and these improvements, with a few remarks on some other points treated of in that paper, in relation to the processes in which the thermic rays are concerned, are now subjoined.

The positive cyanotype process described in Arts. 219, 220, of my papers though beautiful in its effect (especially during the first few minutes of the appearance of the picture), is very precarious in its ultimate success, owing to causes there detailed. The remedies proposed are also only occasionally and partially successful, and, in consequence, this process, though exceedingly *easy* in its manipulations, could not be recommended as practically useful. After trying a vast variety of means to overcome these obstacles to its success, I have succeeded at last, by the simple addition of corrosive sublimate to the ammonia-citrate of iron, with which the paper is prepared. The improved process, therefore, may be thus stated. Mix together equal measures of a saturated cold solution of corrosive sublimate, and a solution of ammonio-citrate of iron, one part by weight of the salt to eleven parts of water. No immediate precipitation takes place, and before any has time to do so, the mixture must be washed over paper, (which should have rather a yellowish than a bluish cast,) and dried. It is now ready for use, and I do not find that it is impaired by keeping. To use it, it must be exposed to the light till a faint, but yet perfectly visible picture is impressed, and till the border (if it be an engraving which is copied) has assumed a pale brown color. Being withdrawn, it is to be brushed over as rapidly as possible with a broad flat brush, dipped in a saturated solution of prussiate (ferrocyanate) of potash, diluted with three times its bulk of gum-water, so strong as just to flow freely without adhesion to the lip of the vessel. All the care that is required, is, that the film of liquid be very thinly, evenly, and, above all, quickly, spread. Being then allowed to dry in the dark, it rarely fails to produce a good picture. And what is very remarkable, it is *ipso facto* fixed as soon as dry, so, at least, as not to be injured by exposure to common day-light, immediately; and after a few days' keeping it becomes entirely so, and will bear strong lights uninjured. By long keeping, details, at first barely seen, come out, and the whole picture acquires a continually increasing intensity, without, however, sacrificing distinctness; and by the same gradations, its color passes from purple to greenish-blue. Some experience, to be acquired only by practice, is necessary to determine the proper moment for withdrawing the photograph from the action of the light. If it be over-sunned, only the darker shades appear; if too little, the whole, though beautifully perfect in the first moments of its appearance, speedily runs into an indistinguishable blot.

The principal obstacle in the way of the employment of gold and silver, as photographic ingredients for the production of negative models, to be used for retransfers, so as to multiply positive copies, arises from the want of absolute opacity in these metals, or their oxides, when in a state of minute division. The same objection does not apply, or applies with much less force, to mercury, which (probably owing to its fluid state, which prevents its particles from acquiring that excessive tenuity which a laminated form would admit, by reason of their capillary forces contracting each separately deposited particle into a sphere) is one of the most opake substances (after carbon) known. I find that this high degree of blackness and opacity may be induced on a mercurial photograph prepared as in Art. 228, by a process which is in itself not a little curious and instructive, as affording a kind of parallel to the stimulating action of Mr. Talbot's second application of nitrate of silver, in his beautiful kalotype process. The nature of the process in question, will be best illustrated by describing the experiment which led to it.

It frequently happens that papers prepared with nitrate of mercury, and the ammonio-citrates, or tartrates, with, or without, addition of tartaric, or citric, acid, fail to exhibit the peculiar properties described in Arts. 228, 229, at all satisfactorily. Indeed, to bring on the peculiar velvety effect there described, a high degree of intensity of sunshine seems to be an essential requisite, as, in a feeble sun, I have never obtained even an approach to it. A paper prepared (Oct. 28, 1842) according to the instructions of Art. 229, in every respect, except in the proportion of tartaric acid (which was somewhat less than that recommended), proved very little sensitive. A strip of this paper, half shaded, acquired after a few minutes' exposure to sunshine, only a feeble brown color over the sunned portion. Being then withdrawn, it was washed over with nitrate of mercury. *Immediately* the sunned portion began to darken very rapidly, while the shaded part was unaffected, and ultimately assumed a deep brown hue. Exposed while yet wet to the sunshine, this passed rapidly to intense blackness, while the portion originally shaded, which had undergone the same subsequent application, and which was now equally exposed to the sun, sustained in the short time required for bringing on this effect, no appreciable change. Indeed, it seemed rather to have become more insensible than before.

Not alone nitrate of mercury is capable of thus exciting, or stimulating, the dormant photographic impression on such paper. To my very great surprise, I found the same effect to be produced by *water* sparingly applied, so as only to moisten the paper. Across the sunned and shaded portions of a strip of the mercurialized paper, exposed till a pale brown was developed in the former portion, were drawn two streaks, one of weak nitrate of mercury, and one of spring water. Both, after a very short interval, passed to an intense brown on the sunned half, the shaded remaining unchanged. Edging the streak produced by the nitrate, was a black border, that produced by the water, was uniform, The *whole* paper was now exposed for a short time to the sun, which rapidly converted to intense blackness, both the streaks on the previously sunned half, while it produced no perceptible change in the other. I found this experiment to succeed on many different varieties of paper, and with very considerable latitude in the dosage of the ingredients. It was most successful in the case of a paper prepared with a cream, formed by mixing one measure ammonio-*tartrate* of iron (strength $\frac{1}{12}$*) and two saturated protonitrate of mercury, leaving out the free tartaric acid altogether, which, among many other doses of these two ingredients, proved also, generally, the most sensitive to light.

Led by these indications, I prepared a paper by washing, first with a weak solution of ammonio-citrate of iron (strength $\frac{1}{20}$), and when dry, with saturated protonitrate of mercury. It was exposed *when barely dry enough, not to feel damp*, with an engraving in a frame to a hazy and declining sun. In about twenty minutes, a very pale, and feeble photograph was produced. Excited, as above, by water, it gained but little in intensity (for it deserves remark, that the *increase* of apparent intensity, produced by either water, or the nitrate, is in direct *proportion* to the force of the original impression, which, as observed, was in this case very faint.) It was then held for about five minutes in the sun (near setting), and, by degrees, and with the utmost regularity of gradation over every part of the picture, each line assumed an inky blackness, the lights and shades being exquisitely preserved in their due proportions, and the ground being hardly perceptibly discolored. The result was very beautiful, and perfect negative photograph.

This singular power of water to excite the dormant impression, strongly recalls the analogous power of moisture, to deepen the tints photographically impressed on auriferous papers, of which an instance is given in Art. 45, and of which a still more striking example is shown as follows. Let a paper be washed first with ammonio-citrate of iron, and when dry with neutralized chloride of gold, and thoroughly dried in the dark. It is then, apparently, almost insensible to light; a slip of it half exposed to the sun being hardly impressed in any perceptible degree in many minutes; yet, if breathed on, the impression comes out very strong and full, deepening by degrees to an extraordinary strength. Treated in the same manner, silver also exhibits a similar property.[*] Nor, indeed, is there any feature in photography more general, or more remarkable, than the influence exercised by the presence of a certain degree of moisture in favoring the action of light, whether direct, or indirect.

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*By this I understand one part (by weight) salt + 11 water.

There is this difference, however, in the excitement produced by simple water, and by the mercurial solution, viz., that the latter is permanent, the former liable to fade; at least I have found this to be the case with the brown tinge produced by it in shade, though, when blackened by a second exposure to sun, no difference is perceived. On the other hand, when the nitrate is used, the brown hue frequently passes to absolute blackness, without any subsequent exposure to sunshine; and in that case the photographs produced have an intensity, and opacity, scarcely, if at all, inferior to that of printing ink.

This high degree of opacity and depth, together with the comparative insensibility of the ground, is evidently capable of being most usefully applied to the production of retransfers. In fact, the photographs so produced, being negative, are so far fitted for the purpose, and if used as models while in this, their transition state, and as it were self-fixed, so far from being injured by the transmission of light, they are actually acquiring additional sharpness and depth, by every beam which passes. By *seizing, therefore, the right point of dryness,* and by using a very sensitive paper to receive the impression, there is no reason to doubt of success in procuring very perfect positive transfers. Some trials I have made, have satisfied me as to the practicability of this, however contrary it may at first sight appear to the usual conditions of photography. Lond. & Ed. Philo. Maga.

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[*] Note added Dec. 21.—The excitement is produced on such paper by the ordinary moisture of the atmosphere, and goes on slowly working its effect in the dark, apparently without *other* limit than is afforded by the supply of ingredients present. In the case of silver, it ultimately produced a perfect *silvering* of all the sunned portions. Very singular and beautiful photographs, having much resemblance to Daguerreotype pictures, are thus produced; the negative character changing by keeping, and by quite insensible gradations, to positive: and the shades exhibiting a most singular *chatoyant* change of color from ruddy brown to black, when held more, or less, obliquely. No doubt, also, gold pictures, with the metallic lustre, might be obtained by the same process, though I have not tried the experiment.—J. F. W. H.

## *Iron-Founding.—From the Glasgow Pract. Mech. & Eng. Mag.*

(Continued from Page 124.)

In taking up the subject of heavy green sand moulding, we enter upon an extensive field of practice, and it will be necessary, as before, to select such examples as appear best adapted to present fair, general views of the subject.

In connexion with some observations on the practice of green sand moulding generally, stated towards the conclusion of our last article, we must, in the first place, remark the introduction of a new element, powdered coal, namely, into the sand, in a state of simple mixture; its office, as before remarked, being to assist the blackening in resisting the penetrating action of the iron. As this action exists just so long as the metal continues in a liquid state, the blackening alone proves sufficient to resist it, in cases of light moulding; whereas, in heavy mouldings, there being a much greater body of metal together, its temperature falls so much the less rapidly, and it, of course, continues its action as a liquid for a longer period. Consequently, coal powder in addition becomes necessary to withstand the attack of the iron. But, further, the proportion proper to be mixed is a matter of considerable nicety, and is dependent on two circumstances; first, the length of time that the liquidity of the metal continues, has a simple relation to bulkiness of the metal; secondly, the temperature of the metal on being poured into the mould, does proportionally increase, or diminish the original intensity of the action on the sand, as well as affect the duration of this action. The correct adjustment of this point must be left to the skill of the workman, derived from his previous experience.

A redundancy of coal in the sand renders the surface of the casting formed in it, *faint;* that is, its outlines are imperfectly developed, or, to use again the language of the moulder, the casting is not sharp. This is the natural and obvious effect of the repellent power of the superabundant gas generated by the heat from the coal. On the contrary, a deficiency of coal proves equally hurtful to the quality of the casting, as the gas produced from it is, in this case, too weak to maintain the well-balanced action of the opponent forces. The iron, having burnt through the blackening, penetrates the sand, which, at the surface, becomes incorporated with the metal, and produces, therefore, a peculiar roughness on its surface. In order to make the casting in the most proper manner, the sand and coal-powder should be mixed, not only in a proportion suited to the body of metal to be cast in the mixture, but also as uniformly as possible.

Pease-meal is not generally used in the heavier flat mouldings, its object being to hold down the blackening applied to mouldings of an intricate, or ornamental character. Now the parts of machinery generally have their surfaces plane, which are, therefore, easily accessible to the trowel and sleeker.

For large castings, the bed of sand, which forms the floor of the foundry, is commonly employed for constructing the moulds, serving thereby the purpose of the *drag-box*. Our illustrative examples shall be drawn chiefly from the structure of a portable non-condensing steam engine of 20 horsepower. To begin with the sole-plate, which will be the first, and most instructive example, it is necessary to describe its construction :—

Fig. 1.

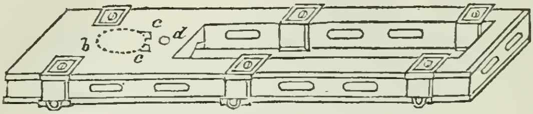


Fig. 2.

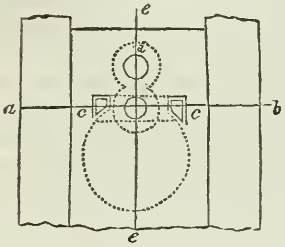


Fig. 3.

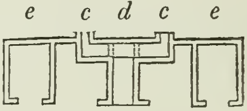


Fig. 4.

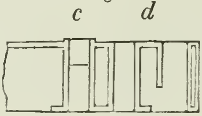


Fig. 5.

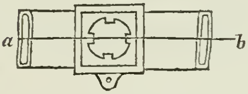


Fig. 6.

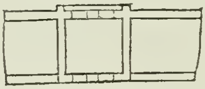


Fig. 1, is an external view of the plate, showing the upper surface. It is arranged to maintain six columns, surmounted by an entablature. At one end, *b*, a platform for supporting the cylinder is cast across the plate, stiffened by a deep flanch at the edge. The position of the cylinder is indicated by the dotted circle. When the cylinder is set in its place, the apertures, *c*, *c*, form continuations of the eduction steam passages ; they are joined into one short branch-pipe below the platform. *d*, is a circular passage for the introduction of the steam into the valve chest. It is projected downwards to the level of the mouth of the eduction-pipe, both passages terminating in one large flanch, by which the respective pipes leading to them, are connected.

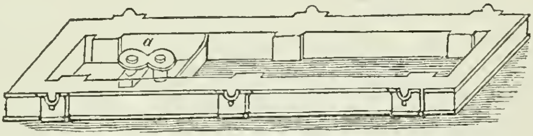
Fig. 2, is a plan of part of the sole-plate, including the steam-ways, showing, in dotted lines, the eduction passage, and the flanch. Fig. 3, is a vertical section of the sole, and the eduction passage at the line, *a*, *b*, fig. 2. The steam passage also is dotted in behind it. Fig. 4, is another vertical section of the same, at the line, *e*, *e*, fig. 2, showing in section both of the passages, *c*, *d*.

Fig. 5, is a plan of another portion of the sole, showing the foundation for a column ; fig. 6, being a vertical section of the same at the line *a*, *b*, fig. 5. It thus appears that the sole is hollow within, and it possesses the form of section shown in fig. 3, all round, interrupted only by the sockets for the feet of the columns. It is a general practice in founding to dispose of the moulding so as that those parts of the casting towards which the greater quantity of metal exists may be undermost. In this way, greater security is found for the soundness of castings at the more important parts.

Now, the sole-plate is, for the most part, entirely open on the under side, as may be seen on referring to the section, fig. 3; it ought, therefore, to be cast with that side uppermost, according to the preceding statement.

For reasons, which will be better understood as we proceed, the pattern of the sole-plate, of the same form externally, is not made open like the sole, on the under surface. Neither are the oblong blank spaces, shown in the sides, executed in the pattern; its cross section at every point is a complete four-sided figure. This form of pattern, will, of course, leave in the sand a plain open space of the same breadth as itself. *Cores* of sand, of the form of the internal void, must, therefore, be introduced into the moulding, to complete the figure of the casting. The fig. 7, exhibits the under side of the pattern. At *a*, the pattern of the steam ways are placed. They are not fixed to the surface on which they stand, but are simply prevented from shifting laterally by small pins, or snugs. They are made solid, so that they, too, like the plate itself, require to be cored out, and, accordingly, the prints, for securing the cores in their positions, are added to the patterns of the flanch, which itself is attached loosely to the pipe patterns. On the opposite side of the main pattern, prints are likewise fastened to receive the other extremities of the pipe cores. In like manner, prints are attached to the upper side of the pattern, to receive the cores for the column sockets, fig. 6; and to the snugs, *s, s,* &c., to core out the holes in them.

Fig. 7.



A level bed in the sand upon the floor, of sufficient extent, is, in the first place, prepared for the pattern, which is then set down upon it, and well bedded in its place, which is effected by blows given to it over the surface—the object being to form a complete impression of the under surface of the pattern. Sand is farther laid in, and rammed about the pattern on all sides, till it be brought up flush with the upper side, forming thereby the parting surface, on which parting sand is strewed.

The next stage of the process is to lay the upper box, or boxes, over the pattern, and to fix them in their places by stakes of wood driven into the floor, which also guide us to replace them accurately when removed. If there be not a single box large enough to embrace the whole of the pattern, two, or more smaller boxes, are placed end to end over it, resting upon the sand external to the moulding, and answering the purpose of a single box. The ramming of these boxes is conducted in the usual manner, except at the end, *a*.

Here, it is evident, that as the platform, or cylinder-plate, is now on the under side of the pattern, the body of sand filling the space immediately above it to the level of the upper side, must be lifted out to get the pattern removed. At the same time, the weight of such a deep body of sand adhering to that in the overlying box, would overcome their cohesion, it would break away altogether. As the box is, therefore, incapable of carrying it with it, it becomes necessary to have this load of sand supported by independent means. An iron frame is cast in open sand of the same form as the sunk space, but somewhat smaller, as allowance for the contraction of the casting, in the course of cooling, must be made to allow the plate to be withdrawn, after the casting is executed. In cases where this precaution has not been sufficiently attended to, the jamming of the plate, inclosed on more than one side, has been the natural consequence, and sometimes the destruction of the casting by consequent fracture. In the centre of the frame, a sufficient opening is allowed for the steam ways. This frame is laid in the bottom of the recess, and as its under-surface now faces the moulding, it must be enveloped on that side in the sand, to protect it from the immediate action of the metal afterwards poured into the mould. To assist its adhesion, the frame, or plate, is studded on the under side with numerous tooth-like projections, which are imbedded in the sand applied. Sand is now thrown in above the plate, surrounding the steam ways, and well rammed, its parting surface being made flush with the upper edges of the pattern of the pipe flanch in the centre, and of the contiguous body of sand, forming the interior part of the moulding, their parting being just over the stiffening flanch of the cylinder bottom. With this preparation, the upper boxes, as already said, are set down and filled.

There are prepared six pouring-gates to the moulding, and eight flow-gates. Of the pouring-gates, or those by which the moulding is filled, two are placed along each side, about four feet distant, and two at the cylinder end of the moulding, while none are made at the other end. This unequal division is necessary, on account of the heavier nature of the moulding at the cylinder end; the design of the whole being to have the moulding filled uniformly. The flow-gates are distributed equally over the moulding. These will be again referred to.

Before lifting off the upper boxes, the pattern being now completely moulded, the latter is so far loosened in the sand, that this may not stick to it, and so spoil the operation. This is effected by gentle jolts communicated to the pattern by means of one or more pieces of rod iron, which have been screwed vertically into the pattern before finally ramming the sand in the upper box, or which merely enter into holes in the pattern. These rods being sufficiently long to pass out through the sand when the box is filled, it is upon their upper extremities that the blows of the hammer are given both horizontally and vertically; the force being regulated by the weight and magnitude of the pattern. The rods, unscrewed if necessary, are now drawn straight out, and the upper box is in readiness to be lifted smoothly off.

After the box is removed, the plate and its overlying core of sand, as it may be termed, deposited in the recess at the cylinder end of the pattern, are lifted out of their situation by arms rising through the core, carrying with them the pattern of the steam ways, which is at liberty to go; for, as we have already noticed, it stands loose on the main pattern. The pattern itself is not in one piece; the flanch, which is separate, is lifted off towards the upper side of the core, and the remainder of the pattern is drawn out by the under side. This is evidently the only mode of extracting the pattern, and shows the necessity in such cases of constructing patterns in two or more pieces to adapt them to the exigencies of the case.

The parts of the mould, in the neighborhood of the pattern, must now, after the box is removed, be pierced with small holes, executed by means of wires traversing the whole body of sand, with the view of rendering the moulding more porous, and of facilitating thereby the escape of the air and other gases. The mould is also watered along the edges, to increase the coherence of the sand.

The pattern itself is taken out by lifting it in all its parts at once, by pins secured into it at several places, so as to be raised in a truly vertical position. This manœuvre is performed by several men, who, while they lift the pattern with one hand, strike it gently, and constantly, with the other, thus continually checking any efforts made by the pattern to tear away the sand of the moulding, and now especially is this remedial application necessary, as the pattern is much more engaged in the lower moulding than in the upper, which, indeed, is the case in mouldings generally. Unavoidable degradation in one, or other, of the two parts of the mould nevertheless do occur, and these the workman repairs with damp sand by means of his trowel.

The moulding is next smoothed all over the surface by the trowel, and a sprinkling of charcoal is then applied, and polished likewise by the trowel. It is, however, omitted for very large castings. Sometimes, also, in order to avoid using too much charcoal, the surfaces are lightly dusted over with sand, finely pulverized through a bag. The moulding is now ready for the reception of the cores, the making and depositing of which claim the particular attention of the moulder, as the figure of the future casting will very much depend upon his accuracy in these respects.

Cores of several forms are necessary for the completion of the moulding. There are, first, the cores for the column sockets, of which there are six; then the cores for the intermediate portions of the sole-plate, of which also there are six, there being two on each side between the socket cores, and one at each end; again, two cores for the steam ways, with several other minor cores, for the holding-down-bolt holes in the snugs at the bases of the columns, as well as for the holes that may be required for the bolting down of pedestals, &c., to the sole. For all these, there are simple prints sprigged upon the pattern at the proper places, the impression of which in the sand serve to hold the cores securely.

As we have already remarked, about the beginning of our last paper, cores must be made not only of the exact size and shape of the vacancies in a casting, whether partial, or thorough, which they are intended to form; allowance must also be made on them for the core-prints, when these are necessary. This allowance then is provided in the cores of the column sockets, for which there are prints on the under side of the pattern, fig. 7. These sockets go through the sole, and are square in the body, and round at each end, as may be understood on referring to figs. 5, and 6, and to the annexed fig. 8, which is a plan of the moulding, showing the cores in their places.

Fig. 8.

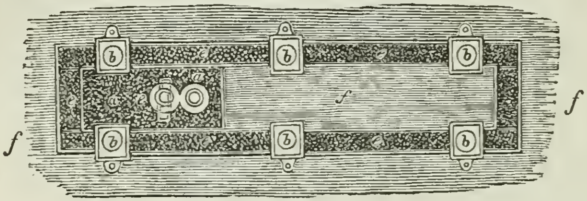


Fig. 9.

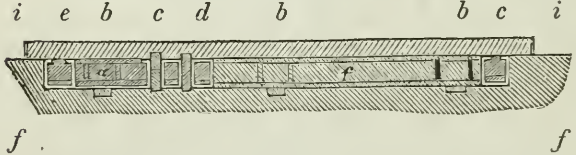


Fig. 9, is a longitudinal section of the moulding, taken through the steam ways. In both figures, *f, f, f*, is the sand of the floor, in which the moulding is formed, constituting the interior, as well as the exterior of it; *b, b*, &c., are the cores of the column sockets, seen in dotted lines in the section; *c, d*, are the cores for the steam ways, which, in fig. 9, are seen projecting in the sand, above and below, filling the recesses made for them by the prints. Figs. 2, 3, 4, explain the shape of them. They are formed in boxes, which open in two, for the purpose of extracting them. These, with all the other small cores, are dried upon hot plates, heated by stoves. At *a*, and *e, e*, &c., the cores are shown, forming the spaces in the moulding intended to be vacant. Near the under side of each, in fig. 9, are shown the plates, indicated by dark lines, which sustain the cores. The whole, however, must be sustained by the bottom of the moulding, leaving a space of the required thickness of the casting. This is effected by placing steeples there; these are simply strips of sheet iron of small lengths, but with double knees, thus [. If the depth of these be just the thickness of the metal, then by placing several of them along the bed of the moulding, they support the cores placed over them, keeping the space clear for the metal—of course, these steeples will be imbedded in the casting, where they are allowed to remain. The double-knee cores at both ends of the moulding, it will be observed in fig. 8, are put together, each in three pieces. In constructing the cores, *e*, *e*, &c., plain square bodies of sand of the dimensions of the interior of the casting, are, in the first place, formed in boxes of the same size, including, at the same time, the iron frames enveloped in the cores. Now, the small cores that are necessary to the oblong openings in the sides of the casting are simply attached in their proper positions to the sides of the main cores, *e*, *e*, &c. They are formed and fixed on by simply applying upon the larger core, an open box of the form required, into which sand is packed, thus causing it to adhere to the main core; when the box is filled, the sand is squared off by a straight edge, flush with the surface of it. It is evident that if the box be lifted off, it leaves its core behind it. All the other smaller cores having been made, and set in their places, the moulding is finally closed, the upper box being replaced, as seen in section, *i*, *i*, fig. 9. This requires to be done cautiously, and in a truly vertical direction, as it now receives the upper ends of the cores which project above the moulding, and also bears upon the other cores, large and small, which do not require any additional security.

When convenient, two or more gates are connected to one central reservoir, all built on the surface of the sand. Gates at considerable distances from others, are usually supplied separately with iron from hand ladles. The other gates that are connected, are supplied from crane ladles, which are conveyed by cranes from the cupola to the moulding. The ladles will be afterwards described. The flow-gates, while the metal is being formed, are plugged with clay-balls, to "keep down the air" in the moulding. These plugs are drawn out when the moulding is filled, and the iron flows up. It is thus judged whether the casting is complete. The plugs must not be prematurely drawn, as by the too free egress given to the air, the bottom of the mould is apt to be disturbed by the air confined in the sand.

When the metal is poured, the "feeders" are immediately applied at the flow-gates. These are rods of iron, which are plunged into the liquid iron, and wrought up and down in it. By this agitative process, the liquidity of the iron about the gates is longer than otherwise maintained. It is, therefore, enabled to supply itself with additional iron from the flow-gates, for it must be understood that in the cooling down of large bodies of metal, the surface sets, while the interior is liquid; and, therefore, when the interior farther contracts, it draws in the surface metal towards the centre, and if not fed as above described, the casting assumes a vesicular structure, which weakens it considerably. To avoid such a result as far as possible, is the object of the agitation produced by the rod.

(To be continued.)

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## *Jeffery's Marine Glue.*

[A recent invention, called Marine Glue, has been produced by Mr. Jeffery, of Limehouse, which demands our attention, as from its extraordinary qualities it is likely to become hereafter of great importance in the various purposes of ship building. We have taken the following account of it for our readers, from the inventor's description.]

Mr. Jeffery, the inventor of this substance, who was one of the early producers of copper plates by galvanic action, considered that the manufacture of copper sheathing for vessels might be improved by that process. But finding that he could not diminish the cost of production below that of plates made by the ordinary method, and that the waste by oxidation on the one hand, and on the other hand, the mischief of foul bottoms when oxidation was checked, formed insuperable barriers to success in the application of this process, he desisted from the attempt. The idea also occurred of applying gums insoluble in water, as a protection for the bottoms of ships; and by combining elastic gum with non-elastic, and charging the whole composition with ingredients destructive both to animal and vegetable life; that such a coating would protect the timbers from the contact of the water, and also prevent any adhesion, or accumulation of animal, or vegetable matter, and resist the attack of the *teredo navalis.* Mr. Jeffery accordingly made a series of experiments, and succeeded in producing a composition likely to realize all his wishes and expectations. He then deposited a sealed paper, descriptive of his discovery, in the Admiralty, with a statement as to the probable effect of the composition, and, at the same time, several blocks of wood were experimentally sunk in Portsmouth harbor, to prove that the marine glue possessed properties most useful and important for ship building, and other purposes.

Every one knows that the timbers which compose a ship, are exposed to constant strain from winds and waves, from the time the ship is launched until she is broken up. One of the qualities required in a substance used to join those timbers, must be insolubility in water, or it would be useless; it must be impervious to water, so as to prevent leakage; it must be elastic, so as to contract and expand according to the strain on the timber, or the vicissitudes of climate; it should be sufficiently solid to fill up the joint, and give strength; it should be adhesive, so as to connect the timbers firmly together. These properties Mr. Jeffery has combined, in an eminent degree, in the marine glue. One of the experiments made to test the power of this glue, was the following:

. Two blocks of African oak, eighteen inches long, by nine inches wide, and four and a-half inches thick, were joined together longitudinally by the marine glue, and a bolt of one and a quarter inch in diameter, was passed through each of them from end to end, and a chain attached to it.

On the next day attempts were made to draw the blocks asunder longitudinally, by means of the hydraulic machine in Woolwich Dockyard, applied to the chain, in the presence of Sir Francis A. Collier, and the master shipwrights of the Royal Dockyards at Plymouth, Portsmouth, Sheerness, Chatham, and Woolwich. A strain, to the extent of nineteen tons, broke one of the bolts, but the junction of the wood by the glue remained perfect. Two bolts of one and a half inch in diameter, were inserted on the following day into the same block, and the strain was again applied, until it reached twenty-one tons, when one of the bolts was broken; the junction of the wood still remaining perfect, and apparently not affected.

Two blocks of African oak, of similar dimensions, were glued together, with bolts at the opposite ends, so that the strain might be applied at right angles, to the junction made with the glue. With the strain of five tons, one of the blocks split asunder at a short space from the point, but the joint remained perfect.

The result of these last experiments was deemed more extraordinary by those assembled, inasmuch as African oak is a very difficult wood to unite.

Numerous experiments have been made to ascertain the best proportions of the mixture constituting the marine glue for various sorts of wood; and in one case, where it was applied to elm, it resisted a strain equal to 368 lbs. on the square inch. This trial was made whilst the block was in a wet state, which state is considered most favorable for the effect of the glue.

Several large pieces of timber glued together, were precipitated from the top of the shears in the Dockyard at Woolwich, a height of about 70 feet above the ground, on to the granite pavement below, in order to test the effect of the concussion. The wood was shattered and split, but the glue yielded only in one case, in which the joint was badly made, and after the third fall. This falling from a height on to a hard substance, is a very severe test of the strength of a joint. The explosion of a shell has greater power in rending wood, but does not produce so great an amount of vibration.

From the elastic nature of the marine glue, it contracts when the timbers to which it is applied are swollen by water, and expands when the timbers shrink from heat, or any other cause.

A block of wood with a rend in it was taken, and the rend filled with the glue. It was then immersed for a month in a mast-pond at Chatham, at a temperature ranging between 30° and 40° Fahrenheit. On taking it out of the pond, the glue, from the pressure of the wood, was slightly squeezed out, so as to present a raised surface above the rend, but after this block had been a month in the Chatham hoop-house, at a temperature from 70° to 80° Fahrenheit, it assumed a concave figure on the surface of the rend. This block experiment is still going on, and it is intended to place the block in the hoop-house and mast-pond alternately for the space of a year, in order to ascertain whether the result will be equally successful. But in preparing the glue, its elasticity may be increased, or diminished, as circumstances may require.

This quality renders the glue most valuable as a remedy to be applied to the rends and fissures of timber; and, in fact, renders defects of that nature of little consequence—a result, of which the practical shipwright will perceive the immense importance. It is also available with peculiar advantages for the seams of vessels, in lieu of pitch; seams which were payed with it about a year since, and were exposed to the heat of last summer, appear but little changed, and are quite free from leakage, although they were executed under very unfavorable circumstances. For the deck seams it will be found peculiarly suited; and where it is used the crew will never have reason to complain of the glue sticking to their feet. The surface of the seams after heavy rains, or from a damp atmosphere, will become slightly convex, and under a warm temperature will become slightly concave; but it will not liquefy by solar heat, and it will, under all circumstances, adhere with its original tenacity. All practical seamen will perceive the vast importance, in point of economy, comfort, and security from leakage, which these qualities ensure, especially in hot climates.

Another important experiment has been made with the glue in reference to its being a substitute for copper sheathing. This composition was applied without poison, to four surfaces of some nearly cubical blocks of wood, and on the other two surfaces, it was applied in combination with poison, equally destructive to animal, as to vegetable, life. After the lapse of twenty-three months, these blocks were taken up, and were found to present the following appearances—small shell-fish were adhering to the four unpoisoned sides, whilst the two sides charged with the poison, were perfectly clean. The whole of the composition was slightly changed in color, but was not deteriorated, or affected, in respect of its useful qualities.

Another most important use of the marine glue, is evidently in its application to the construction of masts. Its power of adhesion, and elasticity, admirably fit it for the purpose of joining the spars of which masts are composed. A great reduction of expense is likely to follow its adoption for this purpose, as shorter and smaller timbers may be rendered available, and most, if not all, of the internal fastenings may be dispensed with.

The following account of some experiments on this point are from daily journals. The masts alluded to, have been glued with such proportions of elasticity given to the glue, which deflect in about the same ratio as the wood itself, or as if the wood were in one solid piece.

"Experiments were carried on, January 4th, and 5th, at Chatham, in the presence of Capt. W. H. Shirreff, Superintendent, and Mr. John Finchman, master shipwright, at the Dockyard, with the marine glue, invented by Mr. Jeffery. The experiments which were carried on last year at Woolwich, with the view of improving its immense adhesive power, and that it would be more difficult to separate the joinings made with it, than it would be to tear the solid wood in pieces, by shots from the large guns of the ordnance, and the result of the trials so convinced the master shipwrights then assembled to consider improvements which might be brought forward for the benefit of the Royal Navy, that they recommended its adoption, and its application to naval purposes was approved by the Lords Commissioners of the Admiralty. The main-masts of the following vessels have been joined with it, under the instructions of Mr. Jeffery. The main-mast of the Eagle, 50-gun ship, was first fitted with it, and it now stands exposed to all the changes of our variable atmosphere; the main-mast of the Trafalgar, 120-gun ship, built at Woolwich, has been joined with marine glue, and appears to be finished in a most substantial manner; and some idea may be formed of the number of joinings, when it is stated, the dimensions of the mast is 125 feet in length, with a diameter of 40 inches. The main-mast of the Curacoa, formerly a 32-gun ship, but at present being reduced to a 24-gun vessel, is in progress of being joined with the composition. The whole of the practical workmen speak highly of its merits, and have expressed an opinion that its general use will save a great amount of labor in placing internal fastenings, which may now be nearly dispensed with. Mr. Jeffery had an officer from Pembroke Dockyard under his instruction, who returned home with a quantity of the composition to be used in laying the decks of the Victoria and Albert steam vessel, for the especial use of her Majesty, and his Royal Highness Prince Albert.

"The experiments formerly made and tested, were undertaken at a period when a high degree of summer temperature existed, and it was imagined by some, that it would be difficult to use it in winter, so as to have equal adhesive, and strengthening powers. In order to satisfy himself on this point, the inventor had several pieces joined together during the present cold weather, and the following is the result of the trials of their qualities:

"Eight pieces of wood 12 feet long, and 6 inches in diameter at one end, and 5 inches at the other, were each cut lengthways into four pieces, and joined together with the marine glue, two of the pieces with a new sample of the composition, and the others in the usual manner, only varying the proportions of shell lac of $\frac{6}{12}$ and $\frac{9}{12}$. These pieces of wood were alternately attached by strong bolts to the floor of the mould loft; and an iron collar and chain having been placed in the centre, the following weights were placed on a balance to shew the deflection, or strain. No. 1, with the new sample, with a strain of 25 cwt., bent 3 inches exactly, and on the withdrawal of the power, returned to its former position with the greatest elasticity. No. 2, with a strain of 27 cwt., only yielded 2⅛ inches. No. 3, with a strain of 27 cwt., bent 2⅜ inches. No. 4, with a stain of 27 cwt., yielded 3⅜ inches, having been joined by the new sample. No. 5, with a strain of 27 cwt., showed a deflection of 2⅛ inches. No 6, with a strain of 27 cwt., only yielded 2 inches. No. 7, with a strain of 27 cwt., bent 1⅞ inches; with 29¼ cwt., 2⅛ inches; with 31½ cwt., 2¼ inches. It was then attempted to break this model mast, and additional weighis were put on, until it amounted to 45 cwt., when the strain made it yield 3¼ inches, and fractured the upper part of the wood, but did not separate the joinings, or thoroughly break the wood, and afforded those present an opportunity of satisfying themselves that the joined pieces were far stronger, in every respect, than solid wood of the same dimensions. No. 8, was tested in a similar manner, and with a strain of 45 cwt., yielded 3½ inches, and at one end the joining opened a little in one direction, which will afford the inventor an opportunity of judging of the best degree of mixture of the various substances of which it is composed. The experiments were carried on at a temperature of 40 degrees, and that was the height of the thermometer in the mould-loft at the time they were completed, 4 o'clock, P. M. on the 5th, it being only 8 degrees above freezing point. The value of the materials and invention has now been completely established, and its importance to her Majesty's Navy will be very great, as it has hitherto been found very difficult to obtain trees of sufficient length and diameter, about 22 or 23 inches, for main-top-masts for first rates; but they may now be made from any number of pieces, and from the nature of the marine glue, they will never be subject to the dry rot.

Another experiment was made by joining two pieces of wood 9 inches square, by 20 inches long, and placed in such a position that 21 cwt. of iron, forming a pile 6 feet high, about 7 inches broad, and 20 inches long, and it bore the whole weight without yielding at the time. On the second day, the wood gave way under the immense pressure, shewing the cement was more powerful and secure, than the solid timbers." We shall, in a future number, enter into further details of the value to the navy of this important discovery.

The extraordinary utility of the marine glue will not be fully appreciated, until vessels, in the construction of which it has been applied throughout, from the kelson to the main-top, shall have been exposed to disasters in which ordinary vessels would go to pieces, or founder, from leakage. In many such cases the superiority of the marine glue will hereafter be manifested, in the preservation of vessels, together with the property and lives of the persons on board.

No attempt is here made to enumerate the various constructions, such as dock gates, piers, aqueducts, floating bridges, &c. &c., to which the marine glue may be applied with advantage; the present design being simply to point out some of its principal qualities as shown by experiment. Naut. Mag.

*March 25th*, 1843.

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## *On the Principles of Aerial Navigation.* By Sir GEO. CAYLEY, Bart.

*Sir*,—Mr. Henson having now published a description of the ærial machine, with which he proposes to make his experiments, and feeling an earnest desire that success may attend the practical development of principles which, however difficult in execution, are, undoubtedly, true in theory; I trust it will not be thought obtrusive in me to state a few leading observations with reference to the present scheme.

The magnitude of the proposed vehicle, will, I much fear, militate against its success. There appears to be a limit in nature to the convenient application of winged surfaces. We have millions of winged insects; hundreds of the smallest descriptions of birds; but the eagle, condor, and albatross, sail unmolested, as the sole tenants of the loftier regions of the atmosphere; and these, the largest of birds, probably never exceed one hundred pounds in weight. Muscular power and animal heat, appear to bear a direct ratio to the carbon consumed in a given time by the oxygen to which the blood is exposed in the lungs; and nature seems to have much exceeded her usual animal limits in this respect, purposely to obtain sufficient power for the flight of birds.* The weight of the body of a bird increases as the cube of its linear dimensions, so that if the length be doubled, the weight will be increased eight-fold; and if tripled, twenty-seven fold. But the surfaces of their wings only increase as the squares of their linear dimensions: hence, in this latter case, if the wings keep the same relative proportion to the increased length of the body, as they did in the original size, they would be too small in the ratio of the square of three to the cube of three, or as 9 to 27, being only one-third part of the proper size to give due support to the weight.

Hence, also, if the original proportions are the most convenient, and appropriate, for the degree of leverage against which the muscular power can act—the most suitable for compactness of structure, and for the covering and warmth of the body—then these conveniences must be sacrificed to the necessity of giving three times greater surface to enable the bird to fly; and, in the structure of the albatross, it is said there is an additional joint, to increase its extent of wing. It is difficult, perhaps impossible, for man to trace all the secrets of nature, as to the limiting causes affecting the dimensions of the different species of the animal creation; though we seem, in the present age, to be getting a glimpse of such matters. The particular degree of gravitation towards the earth we inhabit—the exact force of chemical combination between the various particles of matter, and of general galvanic power over each and all, modified, perhaps, by the mechanical properties of leverage and position—probably form the elements taken into consideration by that Divine mind which called all these powers into existence, to fulfil the benevolent purposes of His will. But it is time to return from this digression, to the particular case in point.

Mr. Henson proposes the machine to have a lateral extension of 150 feet, by 30 in width; thus forming a surface of 4,500 square feet. The extent of leverage, however well guarded by diagonal braces, is in this necessarily light structure, terrific. For, although the wings are not intended to be wafted, the atmosphere, even in moderately calm weather, near the earth is subject to eddies; and the weight of the engine and cargo, &c., in the central part of this vast extent of surface, would, in the case of any sudden check, operate with enormous power to break the slender fabric. In the largest birds, the leverage of the extreme points of their wings seldom exceeds 6 feet; whereas, the extent of wing on each side of Mr. Henson's machine, is 75 feet; therefore, every pound in the central part of this fabric, operates with more than eleven times greater effect of leverage, than every pound of weight forming the body of the largest bird.

This consideration shows that in order to obtain a sufficient quantity of surface to sustain great weights in the air, the extension ought not to be made in one plane, but in parallel planes, one above the other, at a convenient distance, so as to form a more compact fabric, with less extent of leverage. The progressive velocity will prevent these planes from interfering with each other, in giving their due support. If, therefore, so large a surface be contemplated for trying this experiment, would it not be more likely to answer the purpose to compact it into the form of a *three decker*, each deck being 8 or 10 feet from the other, to give free room for the passage of the air between them?

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* The power of consuming the carbon in the blood, for the supply of muscular activity, and animal heat, is best estimated by a comparative view of the number of times one can breathe in a given time. The horse breathes 16 time a minute; a man 18 times; whereas, a common fowl breathes 30, and a pigeon 34 times a minute, according to Prevost and Dumas, as quoted by Professor Liebig.

This vast surface is all extended in one nearly horizontal plane, which is not the form experimentally proved to give the proper lateral stability to the machine. It was remarked in my last letter, that the surface should be made in the form of the letter V, though of a much more obtuse angle. Extensive principles are often shown by very insignificant means; and every school-boy knows that his shuttlecock, whichever way it may be struck into the air, is never off its balance. Several winged seeds are likewise, on this principle, borne steadily on the air. As very little of the support is lost by this mode of constructing surfaces for ærial navigation, when not carried to excess,—whereas, the security of the conveyance is very greatly increased by it,—it ought not to be neglected in an experiment, quite sufficiently fraught with danger, after every precaution shall have been taken.

Aerial navigation by mechanical means alone, must depend upon surfaces moving with considerable velocity through the air; but these vehicles will ever be inconvenient, not to say absolutely inefficient, if to effect this they must have an elevated point to descend from; for, to be of ordinary use, they must be capable of landing at any place where there is space to receive them, and of ascending again from that point. They should likewise be capable of remaining stationary, or nearly so, in the air, when required.

Very great power, in proportion to the weight of the engine, is necessary to answer these, or, indeed, any of the purposes of ærial navigation by mechanical means alone. It is, in fact, the *sine qua non* of the case; and Mr. Henson will deserve great credit if he be able, by any invention of his own, or combination of the inventions of others, permanently to maintain the power of twenty horses, by an engine not exceeding 600 lbs. in weight. If that gentleman do not deceive himself in this estimate of the power he proposes to use, well directed experiments will soon point out the proper mode of its application.

There can be no doubt that the inclined plane, with a horizontal propelling apparatus, is the true principle of ærial navigation by mechanical means, as it is that of the flight of birds; and although it has been fully investigated, and there is nothing new in it, the principle, has, as yet, remained dormant, for want of sufficient power. This principle Mr. Henson adopts, and the requisite power he proposes to supply.

It is not correctly known at what angle with the line of flight the wings of birds are applied; indeed, this probably varies with the comparative size of the wing to the weight of the bird; hence no very accurate estimate of the power exerted can yet be made; but, from sundry experiments with inclined planes, it seems probable that for every thousand pounds weight of the ærial vehicle, eight or ten horses' power will be required.

The larger the surface in proportion to the weight, the less velocity it requires for its support; and as Mr. Henson's machine is said to have a surface in proportion to its weight, exceeding that of most birds, its velocity will not be so great as that of birds. Should he, therefore, fully succeed in his project, the velocity of his flight may be taken at something short of that of the crow, which, in calm air, is 24 miles per hour, and is about the ordinary railroad speed. The direct resistance of the car, masts, and rigging, in the construction of ærial vehicles, will, should they ever succeed, probably put a limit to their velocity, not much exceeding 24 to 30 miles per hour.

It has long since been proved, so far as engineering calculations, founded on tolerably well ascertained data, may be trusted, that elongated balloons, made on a very large scale, and of firm, air-tight materials, may be driven through calm air, by engine power, at a velocity approaching the railroad pace, and, by their buoyancy, carry, whether stationary, or in motion, a considerable cargo. Hence, on a great scale, balloon floatage offers the most ready, efficient, and safe means of ærial navigation.

"The enormous bulk of balloons, as compared with the weight they will sustain, causes the *difficulty* of impelling them, with sufficient speed to be of any utility, either by manual, or engine, power; and this *difficulty*, is, by many truly scientific persons, considered as insurmountable, because they conceive that the bulk, which causes the resistance, must ever be commensurate with the weight of engine necessary to propel them by any species of waftage—and, consequently, as it will not do on a small scale, that it cannot on a large one. It is true, that it requires twice as much gas to sustain a 4 horse power engine, as to sustain one of a 2 horse power (with their loads of fuel and water); but it is not true that the larger balloon, though perfectly similar in make to the smaller one, will, when driven through the air at the same velocity, meet with *double* the resistance—if it were so, the case of steering balloons would be hopeless, and on this mistaken ground many think it a vain attempt. This idea, resting at the very threshold of the invention, and which seems to present an insurmountable barrier, when probed and fully investigated, proves to be false, and the investigation leads to an immutable law of proportion between the resistance, and the capacity to carry weight, or engine power, which, on a very large scale, promises the most satisfactory result.

"If balloons of the respective diameters of one and two, both being spherical, be driven through the air with equal speed, the resistance will be as the *surfaces* opposed to the air, and the surface of the largest will be four times greater than that of the smaller, and hence it will require *four* times the engine force to keep up the velocity:

but the quantity of gas contained in the larger balloon is *eight* times greater than that in the smaller, hence it could sustain eight times as much engine power; but four times that power would keep up the required velocity, and hence it could carry a cargo of the weight of its engine, and yet keep pace with the smaller balloon. The simple terms of the case are, that the surfaces (and hence the resistances) increase as the *squares* of the diameter of the balloon; whereas, the capacity to contain gas (and hence the supporting power) increases as the *cubes* of the diameter.

"From this *unquestionable* law it follows, that if similar shaped balloons vary in diameter as the numerals, 1, 2, 3, 4, 5, &c., the resistance they will meet with in the air, at the same velocity, when compared to the weight (or engine power) they will sustain, will be as 1, ½, ⅓, ¼, ⅕, &c. This is a most important fact, and proves that as the law of relative diminution to resistance is *unlimited*, there must ever be, *theoretically*, some bulk in which any species of first mover, however sluggish in proportion to its weight, would find itself suspended, and its power adequate to propel that bulk with the velocity required."*

Elongated balloons of large dimensions, thus offer greater facilities for transporting men and goods through the air, than mechanical means alone, inasmuch as the whole weight is suspended in the air without effort; and when the invention is realized, it will abundantly supply the increasing locomotive wants of mankind, for which, in due time, it was probably designed. Mechanical flight seems more adapted for use on a much smaller scale, and for less remote distances; serving, perhaps, the same purpose that a boat does to a ship, each being essential to the other.

One great difficulty to be overcome in mechanical flight, is the enormous difference of the powers required to perform it, as birds do, by any direct downwards waft in the first instance, as compared with the skimming action on the principle of the inclined plane. The surface of a square foot, if loaded, as it is in the crow, with a pound weight, would descend perpendicularly with a velocity of 21 feet per second; hence, to sustain his weight, he must press his wings down with that velocity, which is equivalent to lifting his own weight 21 feet per second. Now, if an ærial machine were to weigh 1000 lbs., and it had to be lifted with this velocity, the force required would be that of 38 horses; and Mr. Henson's engine, if loaded in the same ratio, would be a 114 horses' power. The bird even exerts a still greater effort, for he has, in the downward beat, to make good the time lost in the ascent of his wing.

The crow, in skimming, goes about 36 feet per second; during which time, if unaided by any waft to propel him, his descent will be about one-eighth of 36, or 4½ feet. The power required, therefore, cannot be greater than in the ratio of 4½ to 21; and in this case 1000 would, in the skimming action, require a 8¼ horses' power, to maintain it, provided it were performed as in birds, by the surface being moved downwards, when obliquely raised at the hinder portion, so as to continue during this action, the same force of the air applied under the surface, as when the front portion of it is elevated, and the bird skims for a time by its previously acquired momentum. It is not yet ascertained what the actual angle of the bird's wing is, and the absolute power required for propelling ærial vehicles, cannot, therefore, be stated with certainty, though we thus make some tolerable approximation to the truth.

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* From Practical Remarks on Aerial Navigation, by the author of the present article, in *Mech. Mag.*, for March 4, 1837.

Fig. 1.

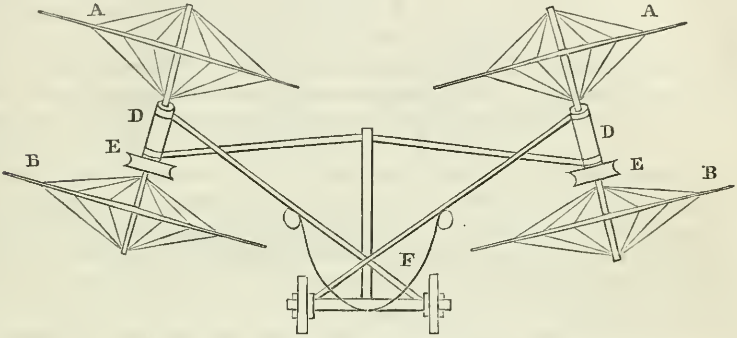
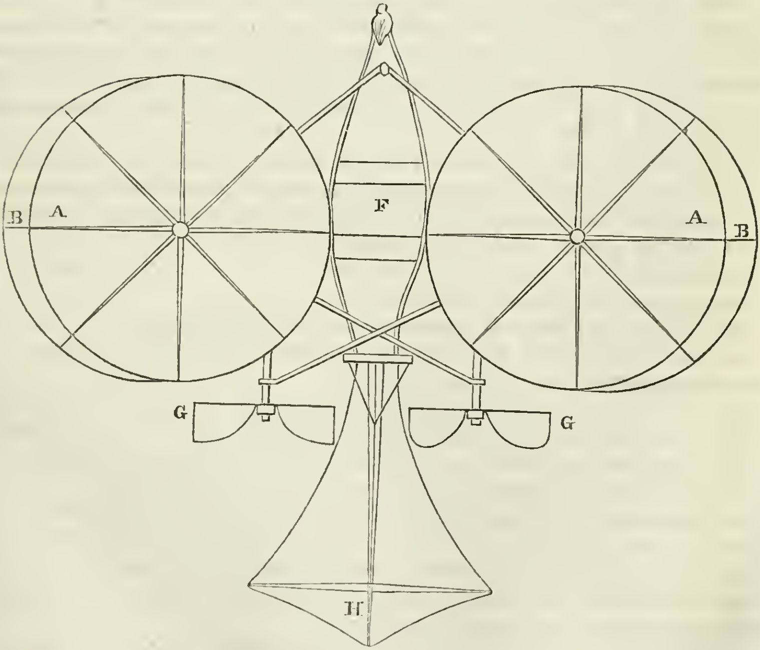


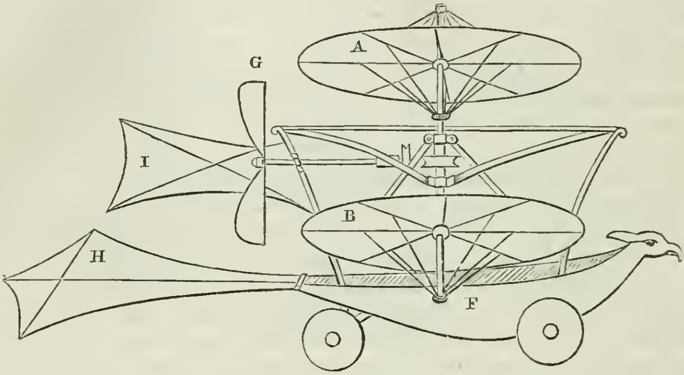
Fig. 2.



The capacity of varying the degree of power to so great an extent in muscular action, gives much greater facility to the flight of birds than man possesses in his steam power, the uniformity of which obliges some more uniform course of action to be adopted.

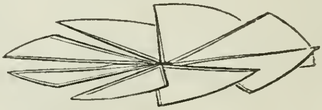
Under this general view of the case, I have endeavored to combine all the requisite principles of action that have been enumerated. Fig. 1, 2, and 3, will exhibit, without tedious explanation, the construction of an ærial vehicle, containing about 530 square feet of surface. Fig. 1, shows an end view in elevation; fig. 2, a bird's-eye plan; and fig. 3, a side elevation.

Fig. 3.



The main surfaces, A, A, and B, B, are here placed one above the other, and each pair are connected together by strong shafts, firmly fixed into sockets at each end of a steel axis, which turn freely in their collars, D, D. These shafts carry a spiked pulley, or drum, E, E, by which they may be turned by a pierced belt, or chain, from the engine in the car, F.

Fig. 4.



The construction of these circular planes is such, that when only required as a stationary expanse of surface, they continue in one even, or rather slightly curved, state, like a very flat umbrella; but when the engine power is applied, to make them revolve in their proper directions, one set adverse to the other, they are immediately, by that act, thrown open, into the form of the flier, fig. 4, and thus the surface, to a great extent, is made to skim, though the machine may be stationary—the upper edge of each section in these fliers being foremost.

It must also be observed, that the two sets of fliers are placed in the obtuse V form, to ensure lateral steadiness to the machine. These may be termed the elevating fliers, to distinguish them from two other smaller ones, G, G, set at a very different angle with their axis, and used for propelling the machine, when the others are stationary; both sets will be put into action gradually, or in any required degree, by friction plates, as is usual in such cases.

If the elevating fliers have a diameter of about 11¼ feet each, they will contain about 100 square feet of surface; yet by this construction, the leverage of the centre of their support, on each side, will only be about 8 feet from the centre of the car, and this will be firmly sustained by the diagonal bracing of the framework.

The framing is also adapted to increase the stationary surface, by being covered with canvas in the obtuse V form down to the edge of the car, and overhead, like a very flat roof, to keep off rain, &c. This surface, as here shown, would be about 130 feet, but, by the addition of a couple of light yards, as in the sails of ships, it might be much increased, with little additional weight.

The broad horizontal rudder, or tail, H, capable of being turned on its hinge to any angle, at pleasure, gives the power of ascent, and descent, when the propellers are used, and forms also the chief means of stability in the path of the flight.

The small vertical rudder, I, is for the purpose of lateral steerage in combination with the two propellers, which, by being used singly will turn the machine with great power; and if one be reversed by the same means as those now used for steam paddles, a still greater lateral guidance can be obtained.

This construction of an experimental machine for mechanical ærial navigation, is not offered in the light of a finished model; but more to show, in combination, certain principles which must be attended to in their construction, to give them a fair chance of success. It will give me much pleasure, if anything experience may have taught me on this subject, can be turned to any account in the present project, which Mr. Henson has now made his own by patent right. I am, however, of opinion, that balloon navigation is that designed for the uses of mankind, on the large scale; but as this letter has already far exceeded its due limits, I must refer such of your readers as may choose again to examine the capabilities of balloon floatage, to an article in No. 708 of your Magazine for 1837. I think it a national disgrace, in these enlightened locomotive times, not to realize, by public subscription, the proper scientific experiments, necessarily too expensive for any private purse, which would secure to this country the glory of being the first to establish the dry navigation of the universal ocean of the terrestrial atmosphere.

*April* 2, 1843. Lond. Mech. Mag.

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FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

## *On the Strength of Cylindrical Boilers.* By Thos. W. Bakewell.

I have just received the July number of the Journal, and hope this short piece may be in time for that of next month.

I should have no objection to make to the analysis of E., could his premises be admitted "mais voila l'embaras," he assumes the parallelism in action of the steam peculiar to the received theory, which, in this instance, is vertical. Referring to the diagram of E., in the July number,* let the half section, A, B, D, terminate at A, and B, by being at those points attached to a solid body, occupying the space below A, B. Now, this change will not, in the least, effect the deductions of E.; for, on the received theory, the tendencies to rupture at D, the leverage = D, A, and the turning point at A, remain untouched; and, if, instead of the half section of boiler above A, D, a strong bar were placed parallel with, and at a small distance from the solid body, A, D, connected to it at each end, by a flexible material, the solution of the parting force at D, would still hold, by a slight variation in the definition of terms.

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* Page 54.

With the half section attached, as above, to the solid body, the operative force to rupture at D, would, on both theories, be as the semi-diameter; and, at B, by the received theory, as the semi-radius: whereas, I contend, that the solid body below A, B, has not effected any change in the conditions of the point, B, which would receive a strain to part horizontally, equal to the quarter circle.

Should, what I have stated, or may state, on this subject, be thought of sufficient importance to induce a trial by experiment, a semi-circle of a flexible material, as here represented, attached to a solid body, would be the simplest method, and form the strongest contrast in testing the two theories; for, at B, the difference would be as 1 to 3.14; or, by the received rule, the semi-circle would uniformly part at A, or B, and by mine, at B.

*Cincinnati, 30th July,* 1843.

ERRATA.

Page 102—20th line, for "*greater,*" read "*quarter.*"
" " 26th " "*greater,*" " "*quarter.*"
" " " " "*directions in one,*" read "*directions; to be resisted in one.*"
" 104—20th " "*pursuaded,*" read "*persuaded.*"

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## *Experiments on the explosive force of Oxygen and Hydrogen gases.*

By James Johnston, Esq.

In 1841 I took out a patent for obtaining motive power from the explosive, and condensing properties of oxygen, and hydrogen gases. In order to ascertain the power and length of stroke which those gases would give when exploded in a cylinder, I commenced, on the 24th of April, 1841, a set of experiments, of which I now give the results.

The apparatus with which I made the experiments, consisted of a strong cast-iron cylinder, accurately bored, so that its diameter was exactly two inches and thirteen-sixteenths of an inch. This diameter gives a surface on the piston of six square inches.

The piston was fitted very accurately into the cylinder. I have ascertained it to work perfectly air-tight. On the top of the piston, there is a cross-head, and spindle, for placing weights upon. The ends of the cross-head work in cast-iron guides.

The gases are admitted to the cylinder by stop-cocks, and are exploded by an electric spark.

I shall now describe the preliminary arrangements made before making each experiment.

I ascertained the weight of the piston, piston-rod, and other appendages, which the gases must move when the piston is put in motion, to be 9 lbs. 5 oz.

I then ascertained, that, to overcome the friction of the piston, it required 5 lbs. 1 oz., together with its own weight; therefore, add 5 lbs. 1 oz. to 9 lbs. 5 oz., and we have 14 lbs. 6 oz., the weight, or force required to overcome the friction of the piston.

I now proceeded to load, as follows, the piston, so that I would give the gases 5 lbs. per square inch of weight to lift.

| | |
|---|---|
| Weight of piston, | 9 lbs. 5 oz. |
| Amount of friction of piston, | 14 " 6 " |
| Amount of weight required to make up the 5 lbs. pr. sq. in., | 6 " 5 " |
| To weight. | 30 lbs. 0 oz. |

This gives 5 lbs. per square inch of weight, as there are six square inches of surface on the piston.

I measured the gases in the cylinder by the height to which I raised the piston. Every inch of distance between the bottom of the cylinder, and the bottom of the piston, holds six cubic inches. When making the experiments, I always raised the piston to the height which I wished it to be at, by placing under the ends of the arms of the cross-head pieces of wood made for the purpose. After the piston was thus raised to its required height, the apparatus was ready for the explosion, as the gases were admitted at the pressure of the atmosphere at the time the piston was raised.

The gases were kept ready for use in a bladder mixed in the proportions of two parts of hydrogen, to one of oxygen.

Having described the arrangements for insuring accurate experiments, I now give the results in the following table, of which the first column gives the quantity of gas in cubic inches, which was placed in the cylinder at each experiment.

The second gives the weight that was placed on the piston in pounds per square inch of its surface.

The third gives the height in inches, and tenths of inches to which the explosion drove the piston.

The fourth gives the height of the barometer at the moment each experiment was made.

The fifth gives the height of the thermometer at the same time.

| Gas. | Weig't. | Height. | | Bar. | Ther. | Gas | Weig't. | Height. | | Bar. | Ther. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | In. | Ten. | | | | | In. | Ten. | | |
| 6 | 5 | 1 | 8 | 29.4½ | 53½ | 21 | 20 | 2 | 7 | 29.5¾ | 54½ |
| 9 | 5 | 2 | 9½ | 29.4½ | 53½ | 6 | 25 | 0 | 3 | 29.5¾ | 54½ |
| 12 | 5 | 4 | 4½ | 29.4½ | 54 | 9 | 25 | 0 | 4½ | 29.5¾ | 54 |
| 6 | 10 | 1 | 0 | 29.4¾ | 54 | 12 | 25 | 0 | 8 | 29.5¾ | 54 |
| 9 | 10 | 1 | 8 | 29.4¾ | 54 | 15 | 25 | 1 | 1¼ | 29.5¾ | 54 |
| 12 | 10 | 2 | 5½ | 29.4¾ | 54 | 18 | 25 | 1 | 4½ | 29.5¾ | 54 |
| 15 | 10 | 3 | 6½ | 29.4¾ | 54 | 21 | 25 | 1 | 7½ | 29.5¾ | 54 |
| 6 | 15 | 0 | 7 | 29.5 | 54½ | 24 | 25 | 2 | 2 | 29.5¾ | 54 |
| 9 | 15 | 0 | 9¾ | 29.5 | 55 | 6 | 30 | 0 | 1½ | 29.7¼ | 57 |
| 12 | 15 | 1 | 6 | 29.5 | 55 | 24 | 30 | 1 | 1 | 29.7½ | 57 |
| 15 | 15 | 2 | 1½ | 29.5 | 55 | 24 | 45 | 0 | 3¼ | 29.8½ | 52 |
| 18 | 15 | 2 | 8½ | 29.5 | 55 | 24 | 50 | 0 | 1¾ | 29.1 | 43 |
| 6 | 20 | 0 | 3¾ | 29.5¼ | 54½ | 24 | 55 | 0 | 1 | 29.1 | 44 |
| 9 | 20 | 0 | 7¼ | 29.5¼ | 54½ | 24 | 60 | 0 | 0¾ | 29.0 | 45 |
| 12 | 20 | 1 | 1¼ | 29.5¼ | 54½ | 24 | 65 | 0 | $0\frac{1}{20}$ | 29.0 | 45 |
| 15 | 20 | 1 | 5¾ | 29.5¼ | 54½ | 24 | 70 | 0 | $0\frac{1}{40}$ | 29.0 | 45 |
| 18 | 20 | 2 | 2 | 29.5¾ | 54½ | 24 | 75 | | 0 | 29.0 | 45 |

In the last experiment, viz., that in which twenty-four cubic inches of gas were exploded under a load of seventy-five pounds per square inch, the explosion was unable to lift the piston; it merely shook the weights.

The above table gives the maximum results of upwards of two hundred trials, or experiments, which I have made on the explosive force of the mixed gases.

In order to show that there is an unaccountable irregularity in the results of my experiments on the gases, I shall now give a few experiments which were made with the same gases, and under the same circumstances.

| Gas. | Weig't. | Height. | | Bar. | Ther. | Gas. | Weig't. | Height. | | Bar. | Ther. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | In. | Ten | | | | | In. | Ten. | | |
| 6 | 5 | 1 | 4¾ | 29.4½ | 53½ | 6 | 5 | 1 | 5½ | 29.4½ | 53½ |
| 6 | 5 | 1 | 5 | 29.4½ | 53½ | 6 | 5 | 1 | 7½ | 29.4½ | 53½ |
| 6 | 5 | 1 | 3½ | 29.4½ | 53½ | 6 | 5 | 1 | 8 | 29.4½ | 53½ |
| 6 | 5 | 1 | 3 | 29.4½ | 53½ | 6 | 5 | 1 | 5 | 29.4½ | 53½ |

In the above eight experiments between the maximum and minimum rise of the piston, there is a difference of five-tenths of an inch. How this difference arises I am at a loss to know. A difference of about the same extent existed throughout all my repetitions of experiments. I have bestowed a great deal of labor, and attention, to find out how this difference arises, and I am satisfied that it has not its origin from any defect in my apparatus, or arrangements. I believe it arises from the difference of strength that may exist between the different sparks of electricity with which the gases were exploded, as it was with the spark from a Leyden jar with which I exploded the gases. I intend making a set of experiments, in order to ascertain this point.

When commencing those experiments, I attempted to explode the gases by the spark which is formed when contact is broken between the wires of a battery; but I found that this spark, although very bright, would not explode the gases. The battery which I used for this purpose, was composed of eight narrow cast-iron troughs, with a plate of zinc in each, measuring twelve inches square.

*Willow Park, Greenock,* 15*th March,* 1843. Edin. New Phil. Journ.

## English Patents.

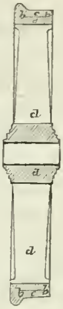
*Specification of a Patent granted to* Thomas Banks, of Manchester, in the county of Lancaster, Engineer, *for certain improvements in the construction of Wheels and Tires of Wheels, to be employed on Railways. Sealed* 13*th June,* 1842.

These improvements in the construction of wheels, to be employed upon railways, consist, firstly, in a peculiar method of constructing the nave, or boss, of such wheels, for the purpose of securely fastening the wrought iron arms, or spokes, in the nave, and preventing their becoming loose.

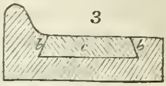
Fig. 1, is a section, taken vertically through the nave of a railway wheel, constructed according to this improvement. The wrought iron arms, or spokes, are shown at *a*, *a*, which may be formed according to any of the well known plans already in use. These spokes, or arms, are then to be welded, riveted, or otherwise securely attached, to a wrought iron ring, *b*, *b*, and then the boss, or nave, *c*, *c*, is formed by casting, or running, melted metal entirely around the ring, *b*, so as to embrace and inclose the inner ends of the spokes, *a*, *a*, and the ring, *b*, *b*, as shown in the figure.

By securing the wrought iron arms to a ring of wrought iron, previously to casting the metal around the ends of such arms to form the nave, or boss, an increased security will be given to the arms in the nave, or boss, and greater strength and durability will be obtained.

2.



3



4.

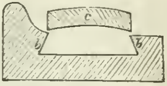
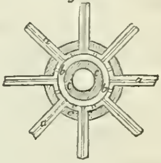


Fig. 1.



The second part of the improvement consists in placing, or inserting a hoop, bar, or segments of steel, iron, or hard metal, in a groove, turned, or otherwise formed, entirely around the outer rim, or periphery of a railway wheel, such groove being properly shaped to receive the steel, or other hard metal. Fig. 2, represents a section, taken transversely through a railway wheel. *d*, *d*, *d*, represent the rim, or periphery, arms, and nave. The improvement consists in forming a groove, *b*, *b*, either dove-tailed, (as shown in the figure, or otherwise,) shaped entirely around the outer rim, or periphery, whatever the material of the wheel; and in placing, or inserting, therein a hoop, bar, or segments of steel, iron, or hard metal, either in one entire piece around the circumference of the wheel, or in smaller pieces, or segments, placed together, end to end, so as to fill the groove formed round the periphery of the wheel. Fig. 3, represents, in section, a portion of the felly, or rim, and tire of a railway wheel; and fig. 4, is a similar section, excepting that in the latter, the steel bar, hoop, or segment, *c*, is represented as about to be placed in the groove, *b*, *b*; which groove is shown as it is cut or formed in the felly, or rim, previously to the steel being inserted. The bar, hoop, or segments of steel, or other hard metal, being heated, are introduced into the groove, and spread laterally, so as to fill, or become tight in the groove, by hammering, or other pressure, as represented in fig. 3.

Steel, or other hard metal, as above described, may be applied to the working surface of the flanch of the tire. A separate groove may be made in the flanch, or the groove shown in the drawing may be extended further towards the flanched side of the wheel, so as to steel that part of the flanch on which the friction, against the edge of the rails, principally takes place. In applying this improvement to the tires of wheels, whether new or old, made according to the usual method, it will be necessary to form the groove to the requisite size and shape; or, if a groove be left, when the tire is formed, it may be enlarged, according to the wishes of the manufacturer, to receive the steel; and the above mentioned hoop, bar, or segments of hard metal, may be easily removed when worn, and renewed from time to time, as long as the general fabric of the wheel is sufficiently firm for use.

The patentee, in conclusion, states that he is aware of steel having been used, before the date of his letters patent, for the tires of wheels, to be employed on common roads and railways, by other persons, and under letters patent, granted to Daniel Gooch, bearing date on, or about, the 28th day of May, 1840, for the use of steel in wheels for carriages, and locomotive engines, to be used on railways, by forging, or welding, together bars of iron and steel; that he does not, therefore, claim the use of steel generally on tires for railway wheels, or the use of steel on such tires, when the iron and steel are welded together in the formation of the tire-bar; but he does claim the improvement in the tires of wheels, to be employed on railways, by inserting a hoop, bar, or segments of steel, or other hard metal, in a groove, turned, or formed, entirely round the rim, or tire, of such wheels as above described.—[Enrolled December, 1842.]

Lond. Journ. Arts & Scien.

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*Specification of a patent granted to* JOHN MULLINS, of Battersea, Surrey, *for certain improvements in making oxides of metals, in separating silver, and other metals, from their compounds with other metals, and in making white lead, sugar of lead, and other salts of lead, and salts of other metals. Patent dated October* 27, 1842; *Specification enrolled April* 27, 1843.

Mr. Mullin's improvements are six in number.

*First*, he produces oxides of lead and other metals by forcing currents of atmospheric air, or oxygen gas, through masses of the metal in a melted state, "heated to the temperature of their respective points of oxidation," and then skimming off the oxides from the surface.

*Second*, to make white lead, he exposes the oxide of lead obtained by the preceding process, which is stated to be much superior to the ordinary litharge, and vitrified massicot of commerce, to the vapors of vinegar, and carbonic acid gas. Or,

*Third*, he exposes a solution of acetate of lead, or other suitable salt of lead, made from "the oxide obtained as aforesaid," to an atmosphere of carbonic acid gas. We quote at length the patentee's description of the mode in which this is effected; it is new, ingenious, and, we think, likely to answer well.

"In chambers, or large jars, of earthenware, or other material, are suspended several large sponges, which are supported in the jars by strings of worsted, so as not to touch the sides of the jar, or one another. Having made a saturated, filtered, and neutral solution of acetate of lead, or of other suitable salt of lead, from the oxide obtained as aforesaid, and placed this solution in a vessel above the top of the jars, and having moistened slightly the sponges with the solution, and also the worsted strings suspending them, the strings are then made to dip into the solution contained in the vessel above the jars, and, by the power of capillary attraction, the sponges are kept constantly moist by a supply of the solution descending down the worsted strings; and the supply can be regulated at pleasure by the size of the strings, or otherwise. Evaporation is continually going on, and crops of salts of lead are formed on the surface of the sponges. The jars are made to communicate with a gas-holder, or other reservoir, containing carbonic acid gas, which gas is made to fill the jars, in order that the sponges may be surrounded with an atmosphere of carbonic acid gas. By the action of the gas, the salt of lead on the sponges is readily converted into ceruse, assisted, probably, by the decomposition of the acid of the original solution. When it has been ascertained that a sufficient quantity of the ceruse has been formed, the sponges are removed, and washed in a vessel of pure water; and if the sponges contain any undecomposed soluble salt of lead, which is generally the case, the water dissolves it; but the ceruse falls to the bottom, on the water remaining at rest. The water is to be reused for forming the solution when decanted from the precipitated ceruse. The sponges are then replaced as before, and the process continues."

*Fourth*, he employs common soot to deoxidize his oxide of lead, and generally for the reduction of all metals from their ores, or oxide.

*Fifth*, when a mass of melted lead, treated by the process just described, contains any silver, the silver, being less oxidizable than the lead, accumulates at the bottom of the pot, whence it is drawn off occasionally to be farther purified and separated.

And *sixth*, to separate iron, the oxides are discharged down a shoot, fixed at an angle of about 30°, formed of wood, or some other non-conducting material, from the bottom of which the poles of a number of magnets project upwards, and to which a slow, lateral, sieve-like motion is given by machinery; the magnets attract and retain the iron, and the oxides pass free.

Lond. Mechanics' Mag.

## METEOROLOGICAL OBSERVATIONS FOR MAY 1843.

| Moon. | Days. | Therm. Sun Rise. | Therm. 2 P.M. | Baromtr. Sun Rise. | Baromtr. 2 P.M. | Wind. Direction. | Wind. Force. | Water Fallen in rain | State of the Weather, and Remarks. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 48° | 62° | 29.30 | 29.72 | W. | Moderate | | Clear. | Flying clouds. |
| | 2 | 38 | 59 | 30.06 | 30.14 | W. | do | | Clear. | Clear. |
| | 3 | 46 | 54 | 30.20 | 30.24 | SE. NE. | do | | Cloudy. | Cloudy. |
| | 4 | 40 | 64 | 30.24 | 30.24 | NE. S. | do | | Clear. | Clear. |
| | 5 | 47 | 65 | 30.20 | 30.20 | SW. E. | do | | Par. cloudy. | Clear. |
| | 6 | 44 | 67 | 30.20 | 30.20 | SE. S. | do | | Cloudy. | Par. cloudy. |
| ☾ | 7 | 56 | 68 | 30.00 | 29.86 | SW. | Brisk | .67 | Par. Cloudy. | Shower. |
| | 8 | 60 | 70 | 29.80 | 29.80 | W. | do | | Cloudy. | Flying clouds. |
| | 9 | 52 | 70 | 29.88 | 29.95 | NW. | Moderate | | Par. Cloudy. | Par. cloudy. |
| | 10 | 50 | 49 | 30.06 | 30.06 | NE. | do | .38 | Cloudy. | Rain. |
| | 11 | 46 | 56 | 29.96 | 29.95 | NE. | do | | Cloudy. | Cloudy. |
| | 12 | 48 | 76 | 29.90 | 29.90 | E. | do | | Clear. | Clear. |
| ⊗ | 13 | 52 | 80 | 29.83 | 29.83 | W. SW. | do | | Par. Cloudy. | Par. cloudy. |
| | 14 | 54 | 80 | 29.80 | 29.83 | SW. | do | | Clear. | Clear. |
| | 15 | 60 | 82 | 29.80 | 29.80 | SW. | do | | Clear. | Light clouds. |
| | 16 | 60 | 79 | 29.70 | 29.80 | W. | Brisk | | Clear. | Clear. |
| | 17 | 58 | 61 | 29.85 | 29.96 | W. | Moderate | | Clear. | Cloudy |
| | 18 | 47 | 64 | 30.10 | 30.10 | NE. | do | | Cloudy. | Cloudy. |
| | 19 | 49 | 71 | 30.10 | 30.00 | E. | do | .01 | Par. cloudy. | Rain. |
| ☽ | 20 | 50 | 70 | 29.85 | 29.80 | E. | do | | Cloudy. | Par. cloudy. |
| | 21 | 46 | 75 | 29.66 | 29.60 | SE. W. | do | | Hazy. | Hazy. |
| | 22 | 52 | 75 | 29.60 | 29.60 | W. | Brisk | .06 | Hazy. | Rain. |
| | 23 | 55 | 74 | 29.65 | 29.65 | W. | do | .12 | Par. cloudy. | Rain. |
| | 24 | 52 | 71 | 29.70 | 29.70 | W. | do | | Clear. | Clear. |
| | 25 | 49 | 70 | 29.75 | 29.75 | W. | do | | Clear. | Clear. |
| | 26 | 52 | 74 | 29.80 | 29.90 | E SE. | Moderate | | Lightly cloudy. | Light cloudy. |
| | 27 | 54 | 68 | 29.78 | 29.78 | N. | do | .06 | Rain. | Cloudy. |
| | 28 | 53 | 65 | 29.86 | 29.86 | SW. | do | | Cloudy. | Cloudy. |
| ☺ | 29 | 48 | 54 | 29.65 | 29.65 | SE. | do | .74 | Rain. | Rain. |
| | 30 | 48 | 71 | 29.65 | 29.65 | W. | do | | Clear. | Clear. |
| | 31 | 56 | 60 | 29.55 | 29.61 | W. | do | | Cloudy. | Cloudy. |
| | | 51.29 | 67.87 | 29.85 | 29.82 | | | 2.04 | | |

THERMOMETER.
Maximum 82 on 15th.
Minimum 38 on 2d.
} Mean, 59.58

BAROMETER.
Max. 30.24 on 3d. & 4th.
Min. 29.30 on 1st.
} Mean 29.835

## JUNE, 1843.

| Moon. | Days. | Therm. Sun Rise. | Therm. 2 P.M. | Baromtr. Sun Rise. | Baromtr. 2 P.M. | Wind. Direction. | Wind. Force. | Water Fallen in rain | State of the Weather, and Remarks. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 42° | 57° | 29.75 | 29.85 | W. | Moderate | | Lightly cloudy. | Lightly cloudy. |
| | 2 | 38 | 64 | 30.05 | 30.05 | W. | do | | Clear. | Clear. |
| | 3 | 57 | 77 | 29.80 | 29.75 | SW. | Brisk | .25 | Cloudy. | Rain. |
| | 4 | 62 | 75 | 29.75 | 29.75 | W. | Moderate | | Cloudy. | Par. cloudy. |
| ☾ | 5 | 67 | 86 | 29.65 | 29.66 | W. | Brisk | .30 | Cloudy. | Par. do.—rain. |
| | 6 | 64 | 73 | 29.63 | 29.70 | W. | do | | Cloudy. | Clear. |
| | 7 | 54 | 72 | 30.00 | 30.05 | W. | do | .1 | Clear. | Clear—rain. |
| | 8 | 59 | 75 | 30.10 | 30.06 | S. | Moderate | | Lightly cloudy. | Clear. |
| | 9 | 64 | 86 | 29.85 | 29 80 | W. | Brisk | | Par. cloudy. | Clear. |
| | 10 | 70 | 87 | 29.70 | 29.64 | W. | do | .18 | Cloudy. | Rain. |
| | 11 | 75 | 70 | 29.60 | 29.65 | SW. W. | do | | Cloudy. | Par. cloudy. |
| ⊗ | 12 | 55 | 76 | 30.02 | 30.05 | W. | do | | Par. cloudy. | Cloudy. |
| | 13 | 56 | 75 | 29.85 | 29.76 | SW. | Moderate | | Cloudy. | Clear. |
| | 14 | 67 | 84 | 29.60 | 29.65 | W. | Brisk | | Clear. | Clear. |
| | 15 | 56 | 78 | 29.70 | 29.70 | W. | Moderate | .12 | Rain. | Par. cloudy. |
| | 16 | 64 | 82 | 29.76 | 29.70 | W. | Brisk | .06 | Cloudy. | Rain. |
| | 17 | 60 | 74 | 29.85 | 29.86 | NE. | Moderate | | Clear. | Clear. |
| | 18 | 52 | 72 | 29.95 | 30.00 | W. | do | | Clear. | Clear. |
| ☽ | 19 | 56 | 76 | 30.06 | 30.00 | SW. | do | | Clear. | Clear. |
| | 20 | 52 | 78 | 30.20 | 30.24 | W. | do | | Clear. | Clear. |
| | 21 | 54 | 82 | 30.14 | 30.14 | W. | do | | Clear. | Clear. |
| | 22 | 68 | 81 | 30.00 | 29.95 | W. | do | | Rain. | Par cloudy. |
| | 23 | 66 | 85 | 29.90 | 29 85 | W. | Brisk | | Clear. | Clear. |
| | 24 | 70 | 88 | 29.70 | 29.70 | W. | do | .1 | Clear. | Clear—shower. |
| | 25 | 68 | 82 | 29.70 | 29 80 | W. | Moderate | | Par. cloudy. | Clear. |
| | 26 | 64 | 87 | 29.86 | 29.87 | W. | do | | Par. cloudy. | Par. cloudy. |
| ☺ | 27 | 70 | 88 | 29.86 | 29.88 | W. | do | | Clear. | Par. cloudy. |
| | 28 | 75 | 81 | 29.84 | 29.79 | SW. | do | | Cloudy. | Cloudy. |
| | 29 | 71 | 85 | 29.75 | 29.75 | W. | do | | Clear. | Par. cloudy. |
| | 30 | 70 | 87 | 29.78 | 29.70 | N. | do | | Clear. | Clear. |
| | | 61.53 | 78.77 | 29.85 | 29.85 | | | .93 | | |

THERMOMETER.
Max. 88. on 24th. & 27th.
Min. 38. on 2d.
} Mean, 70.15

BAROMETER.
Max. 30.24 on 20th.
Min. 29.60 on 11th & 14th.
} Mean 29.85

JOURNAL

OF

THE FRANKLIN INSTITUTE

OF THE

State of Pennsylvania,

AND

AMERICAN REPERTORY.

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OCTOBER, 1843.

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## Franklin Institute.

### COMMITTEE ON SCIENCE AND THE ARTS.

### *Report on the best modes of Paving Highways.*

The Committee on Science and the Arts, constituted by the Franklin Institute, of the State of Pennsylvania, for the promotion of the Mechanic Arts, to whom was referred the following portion of a joint resolution of the Select and Common Councils of the City of Philadelphia, passed January 5th, 1843, to wit: "Resolved, That the Franklin Institute, be requested to communicate to Councils, any information they may think proper, in relation to the best modes of paving highways," REPORT thereon as follows:

(Continued from Page 168.)

2. *Of Pebble Pavements.*—Pavements of rounded water worn pebbles, or small boulder stone, have been, and still are, so extensively used in almost every country, that they must be familiar to all who have ever examined the subject in hand, and will, consequently, require but a brief description.

The *pebble pavements* employed in the city and districts of Philadelphia, are generally constructed as follows:

The natural soil is first excavated to a depth of about 20 or 24 inches below the top of the curbstone, so as to receive a bed of gravel at least 12 inches deep; this gravel is not compacted otherwise than by the occasional passage of the carts hauling it, and the pebbles to the place; the pebbles are set by hand upon the gravel bed, and well rammed three times over, gravel is then spread, and kept upon the surface for some time after the street is opened for travel, in order that all the interstices between the pebbles may become firmly filled.

The pebbles employed, are generally elliptical in their vertical sections, and usually run from five to ten inches in depth, the largest and rudest shaped pebbles, being selected to pave the sides of the street while the rest are reserved, and used, for the middle of the carriage way.

The curbstones used within the city proper, are divided into two classes of the following dimensions:

1st. class, 24 inches deep; 5 ins. thick; and 4 ft. minimum length.
2nd. " 15 " 4 " " 3 " "

The first class, when set, costs about 45 cents, and the second class 30 cents per foot lineal; these curbstones are usually of gneiss rock, and are not dressed as well as they ought to be; indeed, many of them are scarcely dressed at all, but are set in the street, nearly as they come from the quarry.

The curbstones used in the districts adjacent to the city, are of somewhat smaller dimensions, and cost nearly the same per lineal foot, when set.

Curbstones are usually set to show from six to eight inches vertically, clear of the brick gutters, though, in some extreme cases, where a great flow of water takes place, they have been made to show a foot without augmenting their depth; but wherever they project so much, they are disturbed by the frost in such manner, as to require resetting annually—in fact, to possess a proper degree of stability, a curbstone ought not to show above the gutter, more than one-third of its depth.

The streets paved with pebbles have a rounded surface formed in the transverse section, by means of a flat curve, the crown of which rises generally from six to nine inches above the gutter levels.

The gutters formed upon each side of the carriage way, to drain off the surface water to the sewers, are generally laid transversely with bricks on edge, and are, consequently, about nine inches in width.

The footways are commonly paved with bricks laid flat, "*herring-bone fashion,*" and ascend, from the curbstones to the buildings, at the rate of a half inch rise, to one foot base.

The cost of the pebble pavements in Philadelphia, has been determined by long experience, and may be divided into two classes.

*Firstly, where a new street is paved,* inclusive of the brick gutters, and of all materials and workmanship, the aggregate expense is from ninety cents, to one dollar, per square yard of surface, measuring the whole horizontal space between the curbstones.

*Secondly, where an old street is repaved,* in which case, small quantities of new materials are required, and the expense varies from 40 to 50 cents per superficial yard of the whole surface between the curbs.

We learn from the last report of the city commissioners—for which, and other important information, we are indebted to Adam Traquair, their president—that during the year 1842, there were made, under the orders of the city commissioners, 5,590 square yards of *new paving,* at an aggregate expense of $ 5,269.83, *or,* 94 *cents per superficial yard.*

From the same source we have ascertained,that during the same year, 1842, there were executed within the city, 13,012 square yards of *repaving,* at a total outlay of $ 6,305.47, *or* 48 *cents per superficial yard.*

In the district of Moyamensing, *the new pebble pavements* have cost from 90 to 95 cents per square yard; and in some of the other districts, the same quality of work has been done for private individuals, *at* 90 *cents per superficial yard.*

At present it is probable, that 90 cents per square yard for *new paving,* and 45 cents per square yard for *repaving,* are, respectively, fair prices for the pebble pavements, as they now are executed; and even if they were done in a superior manner, one dollar for the former, and a half dollar for the latter, would still be a sufficient remuneration.

The curbstones and footways, under the laws now in force, are paid for by the private individuals whose lots they front, and are not chargeable upon the public treasury.

Such is a brief account of the cost and execution of the pebble pavements of Philadelphia; and we conceive that this kind of paving may be improved in quality, without the necessity of incurring much additional expense.

Thus we think that the gravel foundation ought not to be less than 16 inches deep, though this increased depth of 4 inches, will, at the average price of gravel, add about 5 cents per square yard to the cost of the pavement.

The gravel, instead of being loosely thrown in, ought to be well compacted, by rolling it in *three layers* with a heavy roller, and the top should be finished off with a depth of loose gravel merely sufficient to receive the pebbles.

The pebbles themselves ought to be of good form, and should be sized, so as not to be less than 6, nor more than 8 inches in depth, and all rude, unshapely masses ought to be rejected entirely.

It is not easy to prescribe exact dimensions for stones so irregular as pebbles from their nature are; but in selecting them, none should be received, which, when properly set, would be of greater diameter horizontally, than vertically.

Probably the best shape for these paving stones, would be (to speak in mathematical language) *that of a prolate spheroid, generated by an ellipse, of which the major axis is double the length of the minor one,* such a stone when set in a pavement, would present flat curved ends, and if 8 inches deep, would be 4 inches thick at the middle.

This description of stone ought to be kept in view, and approximated to, in purchasing and selecting suitable pebbles for a pavement; though, as a matter of course, it is not absolutely necessary to be very precise in affairs of this nature, and the inspection will probably be sufficiently rigid, if, from a mass of pebbles of general good shape, we reject all that have greater breadth in their proper position, than they have depth; or, in other words, if we reject all that are flatter than spheres.

The pebbles being carefully selected, and set by hand in the 16 inch foundation of gravel, should be well rammed *thrice over,* and, finally, the whole surface should be covered over 3 inches deep with gravel, which should be allowed to remain under the travel for one month; and whenever from frequent sweeping, or other causes, the gravel works out from between the pebbles, and allows them to project boldly up, the street should then immediately be regravelled, as above, or it will soon break up in consequence of the stone having lost their lateral support.

With regard to *repaving* an old street, we will here remark, that an injudicious practice prevails in this city upon such occasions, of loosening up, and hauling off, a part of the gravel foundation of the old pavement which had become firmly consolidated by use, and supplying its place, at some expense, with loose material, by no means equal, as a foundation, to that which is usually dug up and carried away; this practice, certainly, ought to be terminated, as being not only useless, but positively injurious.

We find that the same practice prevailing in London, as well as here, induced a person named Hobson, in 1827, to take out a patent in England, with the view of obviating its evils, and as some of the remarks in Hobson's specification appear to be judicious, if not novel, we will quote a portion of it, as follows:

"Instead of picking up the ground loose, (as is the practice in the present mode of repaving) ram the ground, on which the paving is to be placed, well down until it is as solid as possible, to a form corresponding with the form the surface of the paving is to take when finished."

"The stones employed should be sorted, so as to be nearly of an equal depth."

A pebble pavement constructed as we have above indicated, *would cost, for new paving, about a dollar, and for repaving, about a half-dollar, per superficial yard;* measuring, as usual, the whole horizontal space between the curbstones, and including the brick gutters in the above prices.

The value of a firm foundation for a pebble pavement, is well exemplified in a statement made to us, by Messrs. Price and Fox, the surveyors of the district of Spring Garden, which was to the following effect:

"That in forming the pebble pavement upon the Ridge Road, where the old turnpike was, the surface of that turnpike road was as little disturbed as possible, and where it was least disturbed, and the least gravel was used, that part has stood admirably, better, indeed, than any other pavement in the district; and no part of the old turnpike road being much below the bottom of the pebble pavement, it has all stood well."

The comparative superiority, in point of durability, of the pebble pavement laid upon the rudely paved surface of the old Ridge turnpike, as described before us, by the surveyors of Spring Garden, is certainly a strong corroborative argument in favor of stable foundations for all pavements. and confirms the propriety of the preference given by us, in a previous part of this report, to a sub-pavement of pebbles, as a foundation for a pavement of dressed stone.

3. *Of stone tramways combined with pebble pavements.*—Tramways are lines, or ribands, of stone, or metal, to receive the wheels of carriages traveling along them; they are spaced from middle to middle, at the usual distance apart of the wheels of common road vehicles, and like the railways of the same name, (which they resemble, omitting the upright flanch) they are designed to carry, indiscriminately, the carriages in use upon the usual highways of the country.

These *tramways*, or trackways, as they are also sometimes called, are usually formed of two parallel lines, or rails, of long stone, from 18 to 24 inches broad, and about a foot thick, upon which the wheels of passing carriages move, whilst the horse-path, or space between them, as well as the rest of the roadway, is usually paved with pebbles.

The leading example of this mode of paving highways, is to be found in the streets of Milan, where the tramways are of stone, a yard in breadth, and where the beauty and excellence of the carriage ways have long formed a theme of admiration for travelers in upper Italy.

Tramways of cast iron plates, 2 inches thick, and 8 inches wide, laid upon stone supports, flush with the surface of the road, have been used with complete success, in the streets of Glasgow, to reduce the traction upon a hill which rises at the rate of 1 in 20; and on this grade they enabled horses to draw up 4 tons with apparent ease; but it must be admitted, however, that notwithstanding their utility, cast iron tramways are objectionable on account of their expense.

John MacNeill, a distinguished English civil engineer, several years ago, stated, in an article on Tramways, that, . . . . . "Trackways of granite have been lately laid on the turnpike road between Coventry and Nuneaton, and are found to answer exceedingly well. In this case, as the horses work two abreast, they are obliged to travel on the stone tracks as they work in the lines of the wheels; in the others already mentioned, the carts, or wagons, are drawn only by one horse in the shafts, by which means he travels on the pavements between the lines, and not on the tracks themselves. This, however, produces no inconvenience whatever, and no obstruction to the horses, from slipping, or any other cause."

Sir Henry Parnell remarks, in relation to this subject, that "the plan of paving which contributes most to diminish the labor of moving heavy weights on roads, is that of forming as hard and smooth a surface as can be formed, with stone for the wheels of carriages to roll upon. This is effected by making use of large blocks of granite, or other hard stone. Roads of this kind, when the blocks are about 16 inches wide, and are laid in parallel lines, are commonly called stone tramways, or trackways."

"On a well constructed road, or trackway, of this kind, it has been proved by experiment, that a London draught horse can draw on the level, *ten tons*."

Stone tramways were used by Sir Thomas Telford, upon the great Holyhead road, with the most decided advantage, to diminish traction upon hills, where the configuration of the country compelled him to adopt inclinations of 1 in 20.

In such cases nearly the same advantage in reducing the draught of carriages, results from the use of tramways, as would be obtained by cutting down the hills one half, and making the surface of the road of broken stone alone.

The commercial road from the West India Docks to Whitechapel, London, which was constructed under the direction of James Walker, C. E., in 1829, is a well known example of the advantageous character of stone tramways.

It is made "with large blocks of granite, five or six feet in length, sixteen inches wide, and twelve inches deep, laid for the wheels to run upon, as on a tramroad of iron, except that there is no flanch. The space between the granite blocks is paved."

The foundations of stone tramways have usually been made either of a rough pavement, dressed off with broken stone of small size, as in Telford's mode of forming highways, or else the tramway blocks have been laid down upon a bed of broken stone alone.

Either of these plans will, doubtless, answer the purpose, but we have reason to believe, that a well rolled gravel foundation, *will generally be sufficiently solid*, if the blocks of the tramways are made two feet in width, so as to distribute the pressure over an extended surface.

Nevertheless, in streets where a very heavy travel is anticipated, it may, perhaps, be found advisable, in preparing the foundations for the blocks composing the tramway, to form under the centre of each line, a pebble pavement, say three feet wide, then to cover this with about two inches depth of gravel, well, and firmly rolled, and, finally, upon this well compacted surface of gravel, to lay down the tramway.

The stone blocks, to form a good tramway, ought to be dressed with their top surfaces parallel to their beds, their ends wrought square, so as to fit close, and their sides scabbled off, so as to be vertical, and nearly parallel when set: *the blocks to be about two feet wide, one foot thick, and from four to six feet in length.*

The upper surfaces of the tramway should be flush with the general outline of the carriage way, and the pavement of pebbles between the lines of stone blocks, ought not to have any more curvature than is due to the general transverse profile of the street.

*Stone tramways*, such as have been above referred to, will, undoubtedly, form a very superior highway; they strongly recommend themselves for use in the American cities, on account of their comparative cheapness, and, excepting for the leading thoroughfares, where a smooth and uniform surface over the whole width of the carriage way, is demanded by a crowded travel, stone tramways would certainly afford all the necessary facilities for transportation, whilst their economy, the ease of traction over them, the smoothness of the motion, and reduction of the noise of passing vehicles, would be found very advantageous.

We may now conclude this branch of the subject, by inviting attention to the great advantages possessed by tramways, in their superior applicability to all inclinations, however high may be the gradient of the street; since, whilst affording upon the intermediate pebbles, a secure foothold for the horses which draw the passing vehicles, the carriage wheels rolling upon the smooth parallel lines of stone blocks, experience less resistance than they meet with upon any other form of stone pavement, and this advantageous property renders tramways superior for some situations, even to pavements of dressed stone, since the latter become too slippery under foot, when applied to streets having a strong grade; and hence, would be inapplicable to the inclinations descending to the Delaware front of Philadelphia, whilst, for such slopes, stone tramways would be particularly suitable.

## SECTION V.

### *Pavements Suitable to Philadelphia.*

In forming an opinion of the kinds of pavement which seem to be the best suited to the circumstances of Philadelphia, the relative cost of the several plans, has, in every case, been closely considered, and that consideration has led us to recommend the adoption of the following system of paving, not, perhaps, as being the best possible, but as the best attainable by a moderate outlay; and, we have, moreover, in our estimates of cost, *sought rather to err in excess, than in deficiency.*

As has been done before by others, it will be sufficient for us to divide the streets into three classes, dependent upon the extent and character of the travel carried by each.

*Streets of the first class,* or the leading thoroughfares of the city, possessing, by our hypothesis, a very heavy and crowded travel, will eventually require a smooth, and durable surface for the whole breadth of the carriage way, *and, consequently, ought ultimately to be uniformly paved with blocks of dressed stone, disposed in the diagonal manner, upon a sub-pavement of pebbles;* this species of pavement, if executed in the substantial manner recommended by us, *will cost about three dollars per superficial yard.*

This price is certainly a large one, when compared with the cost of the same extent of other kinds of pavements, and hence, we presume, that it will be found necessary to employ pavements of dressed stone in Philadelphia, with a very sparing hand, in consequence of the great expense attending them, though, for streets filled with a crowded travel, there would seem to be no other pavement equally suitable.

The cost of the rude specimen of stone block pavement now laid in this city in Chesnut street, between Fourth and Fifth, was about $ 2.50 per square yard of surface, exclusive of the gutter stone, which were a separate charge; and the president of the city commissioners informs us, that the stone blocks delivered upon the sidewalks for the pavement in Chesnut, between Fifth and Sixth streets, cost $ 2 per square yard of the surface they will lay; and that the total expense of that pavement, will not, probably, exceed $ 2.50 per square yard, or the same as that of the pavement east of Fifth street.

In forming pavements of dressed stone for carriage ways, it is necessary to confine their application to those streets which have gentle inclinations, since, if applied upon hills, they would prove too slippery for advantageous use by horses.

It is probable that the inclination in Chesnut street, descending eastward from Fourth street, which has a grade of $2\frac{9}{10}$ feet rise, to 100 feet base, or 1 in 34, is as steep as any upon which the use of dressed stone pavements would be advisable; and it would not seem to be expedient to employ them upon any of the hills descending to the Delaware front of the city, since, excepting Spruce street, where the descent is gentle, they have gradients varying from *seven* to *nine* feet rise, for an hundred feet base, or inclinations from 1 in 14, up to the strong grade of 1 in 11.

*For streets of the second class*, or those of medium travel, which include the majority of the public highways of Philadelphia, *we recommend the employment of stone tramways, combined with pebble pavements*, such as have been briefly described in the fourth section of this report.

A pavement of this nature, though of quite an imperfect character in point of materials and workmanship, was laid in the year 1837, in Arch street, between Twelfth and Thirteenth, which is still in tolerable order, though it has received but trivial repairs since being put in use, notwithstanding that the stone blocks composing the tramways, were too soft, of unequal texture, and had scarcely received any dressing to cause them to fit each other, or to bring their surfaces into line.

We regard this experiment, in view of all the circumstances attending it, as being signally successful, and this fact, when superadded to the favorable considerations we have previously mentioned, and to the successful use of stone tramways elsewhere, appears to us to offer the strongest inducements for extending the use of pavements of this nature here.

The stone tramway blocks employed in Arch street, cost 37½ cents per lineal foot of each line, or if we suppose two tramways, or four lines of blocks, to be laid in a street of 26 feet carriage way, they would, at that rate, clear of the intervening pebble pavement, cost about *fifty cents* per square yard of the whole surface between the curbstones, or, in other words, they would exceed the cost of an ordinary pebble pavement, as follows, if we include with the tramways, the intervening pavements of pebbles with which they are combined, to wit:

Taking for example 9 ft. lineal of pebble pavement with a 26 ft. carriage way, we should have 26 sq. yds. at 50c., $ 13.00

Now, taking 9 ft. lineal of pebble pavement, and stone tramways combined, we should have 36 lin. ft. of blocks at 37½c., $ 13.50

26 sq. yds. of pebble pavement less $2 \times 4 \times 9 = 8$ sq. yds. occupied by the tramway blocks, if 2 ft. in width, or $26 - 8 = 18$ sq. yds. peb. pav. at 50c., - - 9.00

Or 26 sq. yds., at 86½c., = - - - - - $ 22.50

Difference, $ 9.50

Or $\frac{\$ 9.50}{26} = 36\frac{1}{2}$c. per square yard.

Hence, from the above calculation, it appears that if a 26 feet carriage way were laid with two stone tramways, and pebble pavements combined, then, at the prices assumed above, such a pavement would cost 86½ cents per square yard of the whole surface, or 36½ cts. more than the general average cost of *repaving* a street in a proper manner with pebbles alone.

Since the tramways in Arch street, however, were formed of stone of smaller dimensions, and inferior quality, to those which we recommend for use, the material of the latter would cost more.

Nevertheless, since, in repaving streets, we do not contemplate the removal of the existing consolidated gravel foundations—a source hitherto of considerable unnecessary expense—since, contracting for large amounts of stone tramway blocks at once, would reduce the price per foot lineal, and, since the tramway stones themselves would occupy about one-third of the surface of the carriage way, in a street of the common width of 50 feet from house to house; we entertain the opinion, that to repave a street, already paved with pebbles, in a proper manner, and insert suitable stone tramways, two in number, or four lines of stone blocks, *would not cost more than one dollar per square yard of the whole surface between the curbstones, if the usual brick gutters are used.*

Such a price for a good repaving, and introducing stone tramways into our streets, would seem to be within the compass of moderate means; and hence, we are the more strongly induced to request the particular attention of the city authorities to pavements of this species, and earnestly to recommend their gradual adoption for the great majority of the highways of Philadelphia, or streets of the second class, as we have designated them.

*For streets of the third class,* being those which carry the least travel, and include the minor streets, with all the lanes, and alleys, we recommend in general, a continuance of the present mode of paving with water worn pebbles, employing, however, the improvements which have been suggested; and employing, too, in some of the various alleys which carry much travel, a species of tramway formed of smaller blocks than in the main streets; since a precaution of this kind appears to be necessary in some of them, as the cart-wheels traveling always on the same track, are found to destroy the pebble pavements very rapidly.

Such pebble pavements when composed of stone of proper shape and quality, averaging about 6 inches in depth, and set in a sufficient bed of gravel, appear to form the cheapest, and most suitable surfaces for streets, lanes, and alleys, where the travel is not great, and if they be executed as we have proposed, *the cost of new paving streets in a proper manner, with good pebbles, will not exceed one dollar per square yard, whilst the average cost of repaving, will, probably, fall short of a half dollar for the same extent of surface,* since, as we have before intimated, we would not, in repaving a street with pebbles, attempt to pick up, and remove the existing well consolidated gravel foundations, where yet of sufficient depth, but would simply add as much new gravel as might be found necessary to restore the street pavement, when finished, to its proper height and profile.

This course would be both less expensive, and less laborious, whilst it would make a better pavement than the method usually pursued at this time in repaving our streets.

In each and all of the above plans, the gutters and curbstones may be formed as is at present customary, though it would be a great improvement, if stone gutters, and cut granite curbing joggled together, were more generally introduced into our leading streets.

In addition to what we have said in reference to *pebble pavements*, we would recommend that the pebbles employed, *should be, as far as practicable, sorted into sizes*, so that the depths of the pavements formed with them, may be as uniform as possible; and so that no necessity shall exist of intermixing large and small stones in the same pavement at random, which tends to produce inequality of surface, and is, doubtless, a source of instability.

In a pavement of dressed stone, the diagonal system might be brought into play, by a "*herring-bone*" disposition of the stone blocks, as in the brick footways, if it were not for the necessity which would thence arise, of hewing all the stones like bricks, to exact dimensions; a mode of proceeding, which would, to some extent, enhance the cost of the pavement, without apparently producing a commensurate benefit.

## SECTION VI.

### *Plans and Specifications of the Pavements recommended.*

In the event of the paving and repaving of Philadelphia being annually let out *by contract*, at such prices as may be fixed by the public competition of responsible men—the propriety of which we shall discuss in the next section of this report—it will be proper in all cases to accompany the contract by a detailed specification of the work to be done, which will form, in fact, a part of the article of agreement between the parties, and which ought to be illustrated, when necessary, by drawings upon a large scale publicly exhibited, and explained to all applicants at the time of giving out the contracts.

This plan of proceeding is that which, for many years, has been customary in letting out the work to be done on the public improvements of the country, and has been shown by ample experience to be both explicit and satisfactory.

We, therefore, propose in this section, briefly to indicate some of the leading points which ought to be embodied in drawing up specifications to govern the construction of the three kinds of pavement which have been recommended by us for adoption; leaving the details, however, to be filled in by those who may have charge of the work, on the part of the city.

*A Specification for a Pavement of Dressed Stone, should provide;*

1. That the stone themselves be of uniform quality for any one street, and of hard, tough, and durable rock, well rammed when set.
2. That the stone blocks be rectangular parallelopipeds, nearly

cubical in shape; that all the sides be wrought at right angles to each other, or full to the square, and in such manner, that, when set, no joint shall show an opening of more than one quarter of an inch, whilst, in general, they shall be but three-sixteenths.

3. That the depths of all the blocks shall be, uniformly, *exactly eight inches;* that the breadths may vary from 7 to 9 inches, and the lengths from 8 to 10 inches, provided, however, in case of any variation from the standard breadth of 8 inches, sufficient stone of each breadth shall be furnished to form a complete diagonal course with its triangular closers, and that the separate breadths employed, shall be all determined by iron gauges, applied by those who dress them, and marked with paint upon the showing surface of each stone, as fast as they are dressed off, so as to facilitate the laying down of the pavement.

4. That in point of materials and workmanship, the prepared stone when delivered, shall be fully equal to duplicate specimens dressed to the requisite fineness of joint, and submitted by every contractor along with his proposal.

5. That the transverse outline of the finished pavement shall be formed by causing the stone blocks to rise at once from the gutters one and a half inches, the projecting angle thus formed being either *rounded, or chamfered off*, as soon as the pavement is set; that the surface then shall form a flat curve, having an average ascent of one-fourth of an inch to the foot, from the sides to the middle of the streets, so that in a carriage way 26 feet wide, inclusive of gutters, the crown of a pavement of the proper transverse profile, would have an elevation of 4½ inches above the gutter level.

6. That the foundation shall consist of a pebble pavement, formed upon a well rolled gravel bed, of 12 inches average depth; that this sub-pavement shall extend from curb to curb, be, upon its surface, parallel to the profile fixed for the street, and be dressed off to receive the stone blocks with two inches depth of gravel, well compacted under heavy rollers, and accurately brought up parallel to the proper profile of the finished pavement.

7. That the stone blocks shall be disposed diagonally in the pavement, in courses forming angles of 45° with the axis of the street, and running forward towards the right hand; that these courses shall be terminated next the gutter stone, by triangular closers accurately dressed to fit.

8. That the gutters, and curbstones, shall be formed by long blocks of stone in the usual manner, the former being furnished, and laid, by the contractor for the pavement of dressed stone.

9. That the pavement, when finished, shall be covered over with gravel three inches deep, which shall remain on for one month after the street is opened to the public travel, in order to insure the complete filling of all the joints, and save the new pavement from concussion, until it has had time to consolidate.

10. That throughout its whole progress, all the work connected with the pavement, shall be subject to the inspection, and approval, of some officer of the city; and that the finished pavement shall not

be received from the contractor, until that officer shall certify that it has been executed in strict conformity to the specification, and contract, and to his entire satisfaction.

11. That the finished pavement shall be measured by an officer of the city; and that the contractor shall be paid the stipulated price for each *superficial yard* of the whole horizontal surface between the curbstones, inclusive of the intersections of the streets, contained within the lines of the curb produced, where they are paved by the same party.

### *A Specification for a Pavement of Pebbles, should provide;*

1. That the stone shall be of good spheroidal shape; that they shall be river pebbles, and that they shall have an average depth of 6 inches when set.

2. That the average depth of the gravel foundation shall be 16 inches, or 13 inches deep next the gutters, and 19 inches at the crown, the base line being level from side to side.

3. That the transverse profile of the finished pavement, shall be a flat curve, having, on both sides, an average rise from the gutters to the middle, of about half an inch to the foot, so as to bring the crown of a carriage way 26 feet wide, up to an elevation of 6 inches above the gutter level.

4. That the main body of the gravel foundation shall be formed in at least two layers, well consolidated separately by rolling, and dressed off with only the quantity of loose gravel which may be actually necessary to set the pebbles properly.

5. That in setting the pebbles they shall be placed in absolute contact with each other, and that they shall be thoroughly rammed thrice over.

6. That the best shaped pebbles, shall be selected, and set to form the middle of the carriage way, while the ruder ones should be employed in paving the sides of the streets, next to the gutters.

7. That the gutters are to be formed of bricks set on edge, in the manner now usual in the city.

8, 9, and 10. Same as the 9th, 10th, and 11th points of the specification for pavements of dressed stone.

### *A Specification for Stone Tramways, combined with Pebble Pavements, should provide;*

1. That the transverse profile of the street, the quality of the pebbles used, and the general mode of forming the pavement, should be the same as is provided for in the specifications for pebble pavements.

2. That the second layer of the gravel foundation should be brought up by rolling, precisely parallel to the intended outline of the street, and to the proper height for receiving the tramway blocks, beneath which, in particular, it should be thoroughly consolidated. The tramway blocks should then be set upon this well rolled surface, and the remainder of the pavement should be finished off flush with their surfaces, with water worn pebbles, in the usual manner.

3. That the tramway blocks should be composed of a hard, tough, and durable rock, dressed with the top and bottom beds parallel, having their ends squared off, so as to set a joint of three-sixteenths of an inch, whilst their sides should be roughly scabbled, so as to be nearly square with the beds. The dimensions of these blocks to be 2 feet wide, 1 foot thick, and from 4 to 6 feet in length, each.

4. That the four lines of stone blocks forming two tramways in a street, should be spaced equally at 5 feet apart from middle to middle, and should be set with their top surfaces flush with the prescribed outline of the street.

5, 6, and 7. Same as the 9th, 10th, and 11th points of the specification for pavements of dressed stone.

Such, in brief, are the principal points which ought to be embodied in framing specifications for the three species of pavements referred to; but there are a number of minor particulars, which, with the above, should be set out with the minute particularity usual in drawing the specifications of works of engineering, of which, in point of fact, the formation of highways is but a branch.

In the event of putting under contract the pavements of Philadelphia, proposals from responsible men should be invited through the press, for, at least, one month previously; and plans, and sections, of the several pavements, drawn upon a large scale by the city surveyor, should be prepared, and publicly exhibited. Whilst, at the same time, printed copies of the specifications, designed to control the execution of the work, should be furnished to all applicants, and explained, if necessary, by the proper officer, so that they may be clearly understood by those who propose to act under them.

With these precautions in explaining, and illustrating, beforehand, the work to be done, combined with a judicious selection of the men to do it, there will be no difficulty in finding good contractors to construct the pavements here, in a manner much superior to that at present practiced, whilst their expense, at the same time, would, undoubtedly, be diminished.

## SECTION VII.

### *Superintendence and Mode of Executing the Work.*

Experience upon the public works of the country has completely shown, that by far the most expensive mode in which States, or Corporations, can execute works, requiring manual labor, is to employ hands to do them by the day.

On the other hand, experience upon the same works, has also demonstrated, on a large scale, that the cheapest mode of doing work is by contract.

An objection is commonly made to contracts, upon the ground that in consequence of its being the direct interest of the contractor to slight his work, it is difficult to get it done in a sufficiently good manner.

This objection is, however, only partially valid, since the country is full of examples of excellent work done by contract. And, in fact, to procure good work from contractors, if the specifications are explicit, and the superintending officer competent to the duties of his station, but two things are necessary, to wit:

1. *That the prices of the work should be fair.*
2. *That the supervision should be stern.*

To secure the first, it will be necessary to open the work to public competition from responsible men, and to let the work at its value only to those, who are in every sense, competent to execute it.

To secure the second, it is merely requisite that the superintending officer should be honest, competent, and firm.

Though it may be true that some of the worst work in the country has been done by contract, it is equally true that some of the very best quality has also been executed in the same manner, so that no sound argument against the contract system, can be based upon the fact, that bad work has been done under it, since, that such has occasionally been the case, is almost wholly owing, either to a culpable laxity of supervision, or to indirect influence having been brought to bear upon the officer in charge of the work.

Several of the members of this committee, from their professional service upon the public works, have it in their power to state cases which fell under their own observation, where work done by the day for corporations, even under apparently good supervision, has cost far more than similar work executed for the same corporation, or in the same section of country, *by individual contract.*

This course, however, does not seem to us necessary, and might not be agreeable to persons connected with the works referred to; we shall, therefore, omit the citation of particular examples, and, backed by the experience of the country in analogous affairs, we will confine ourselves to expressing the decided opinion, *that all the paving and repaving of Philadelphia, ought to be annually let out by contract, to the lowest competent and responsible bidder, in an open competition, by proposals previously invited by ample public notice.*

To let out the formation of the public highways by contract, carries with it the necessity of placing the execution of the work under a rigid, and intelligent superintendence; and as the construction, and repair of highways is but a branch of the profession of the civil engineer, it seems to us that the most appropriate superintendent for the public highways, would be *the city surveyor,* who, from the nature of his office, should necessarily be acquainted with the elements of engineering, and, therefore, be much more competent to direct the progress of affairs of this nature, than the worthy citizen to whom they are now confided, who, being selected from the people without any particular regard to their knowledge of these subjects, cannot, in general, be expected to possess the requisite information.

In recommending, then, upon the score of economy, that the work upon the highways of Philadelphia, should be done by contract, *we also recommend that those contracts should be rigidly executed under the orders of the city surveyor, and his assistants.*

## SECTION VIII.

### *Concluding Observations.*

We are here induced to remark, that the great cost of pavements of dressed stone, on the one hand, and the comparative cheapness of stone tramways, upon the other, induce us to request the particular attention of the authorities of this city, to pavements of the latter description, as being, probably, the most suitable for the largest portion of the public highways.

Stone tramways possessing such advantages, in point of reducing the draught of the horses employed upon them, and being particularly applicable to hills, such as those descending to the Delaware front of the city, we would suggest the propriety of laying down tramways at an early period, in some, if not all, of the east and west streets, from Front street to the river.

In connexion with the subject in hand, we would recommend the gradual introduction, throughout the leading streets of the city, *of stone, instead of brick gutters,* the latter requiring frequent repairs, and exposing an immense number of joints to allow the filtration of water to injure the foundations of the pavement, as well as to admit of the injurious action of frost.

Gutter stone ought to be hewn from a hard, and durable rock, in lengths of from 4 to 6 feet; they should be about 12 inches wide, by 6 or 8 inches deep, or thick, and should be so dressed, that, when set, the joints shall be close, and the surface regular.

The curbstones commonly employed here, appear to have sufficient dimensions as prescribed by ordinance of councils, except, perhaps, in thickness, to which, a small addition would be desirable.

In setting curbstones, it would be a great improvement, if their joints were more closely dressed, and if an iron dowel were inserted vertically in each joint, and run with sulphur and sand, to prevent one stone from being pushed outwards, independently of another.

It is moreover to be hoped, that since the curbstones are at the expense of those private individuals whose lots they front, our citizens will more generally employ curbstones of well dressed granite, tongued and grooved together, like those fine specimens recently placed, by our enterprising townsman, Dr. Swaim, in front of his property, at the corner of Seventh and Chesnut streets, which, besides their promised durability, are certainly an ornament to the pavement.

The brick footways, also, admit of being essentially improved, by paying more attention to their foundations; thus, if, instead of employing a little loose sand for that purpose, *six inches* in depth, of good gravel, well rammed, in, at least, two successive layers, were used to receive the bricks, a decided improvement in the evenness, and stability of the sidewalks would be the result; or if, still better, the bricks were laid with good strong mortar, upon a bed of concrete from *four to six inches thick,* resting on a well rammed bed of gravel, dressed off to the proper slope; in that case our "*herring-bone*" brick pavements* would leave nothing to be desired in point of durability, and smoothness of surface, especially if concealed gutters should come into use, instead of the open ones now employed.

As an evidence of the great durability which may fairly be expected to result from the employment of brick footways *upon solid foundations,* we refer to the well known promenade along the fore-bay, in front of the wheel-house, at Fairmount; this is paved flatwise, with the usual quality of bricks, laid directly, with a little gravel, upon the solid foundation furnished by the masonry of the head arches; and, though this pavement has been exposed to a very considerable foot travel ever since it was placed there, in the year 1822, or, *twenty-one years ago,* it has never required any repairs whatever, and is, at this moment, in excellent condition.

Since a considerable part of the expense and trouble of laying pavements of dressed stone in the diagonal manner, arises from the necessity of cutting, and fitting, triangular closers next to the gutters, it is worthy of consideration, on the part of those who have charge of the highways, whether this may not be wholly avoided, and the general pavement cheapened, by employing next to the gutters on both sides, a band of pebble paving, about two feet wide, which would economically obviate the difficulty referred to; and yet in a 26 feet carriage way, (if we allow two feet for both gutters,) a width of 20 feet of dressed stone pavement would still remain in the middle, to carry the travel of the street.

Although, for apparently sufficient reasons, we have reluctantly declined recommending a foundation of concrete, for pavements of the first class, nevertheless, if there be any single square of leading thoroughfare within the city, where all the iron, gas and water, pipes are laid, the private attachments to them all made, and the sewers completed, so that no necessity of disturbing the street is likely to occur for many years, *then, in such case, it may be advisable to lay a dressed stone pavement upon a uniform foundation of good concrete, at least one foot in thickness,* since there can be no doubt, whatever, that a pavement laid upon such a foundation, if well underdrained, would be as durable as the materials composing it, whilst few, if any, repairs would ever be required, until, in future time, complete renewal should become necessary.

The positive tone in which we anticipate great durability for a suitable pavement laid upon a well underdrained bed of good concrete, is amply justified by the experience upon the Highgate Archway road, at London, which, under the skilful management of Telford, was, by the judicious employment of concrete foundations, in a place far more unfavorable than any which exist here, converted from one of the worst, into one of the best, and most durable, roads within the limits of the British Empire.

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* *Hexagonal bricks* have the most suitable figure for the purposes of paving flatwise since they may be so laid that none of the sides will be parallel to the line of travel, and thus secure the advantages of the "herring-bone" disposition; whilst, at the same time, from their form in plan, they resist tilting, and are but little liable to the breakage which may be witnessed in all old pavements, where bricks of the usual figure are employed.

Prior to concluding this report, it has occurred to us, that it would be proper to speak more specifically upon the subject of the drainage of Philadelphia; it appears from an approximate soil map, prepared at our request, by the assistant city surveyor, with the aid of an officer of the gas works, well acquainted with the various soils underlying our pavements, that a considerable portion of Philadelphia is built upon a sandy loam of such porosity that it drains with facility to lower levels, any water which may be thrown upon it, and preserves naturally a comparatively dry surface.

Another considerable portion of the city stands upon made ground, scarcely more retentive of water than the sandy loam above referred to.

Of course, then, in the districts distinguished upon the soil map by this porosity, *underdrains* to prepare the ground for the reception of pavements, will scarcely be necessary; but they may be confined with advantage—at least for the present—to the clay district, where the subsoil is retentive of water, and, therefore, needs underdrainage before it can form a suitable foundation for a pavement of any kind.

The soil map which we submit, is merely approximate in its character, and being solely designed to carry *a general idea* of the character of the soils immediately underlying the pavements, it will require verification, before it can be safely made the basis of a system of drainage.

Inasmuch as the whole city reposes upon a substratum of open gravel, at a greater, or less, depth beneath the surface, and as this porous stratum is pierced, in almost every instance, by the old public wells, now abandoned, and arched over; it is worthy of consideration whether these wells cannot be made to subserve, to some extent, the purpose of underdraining the highways, since this is a mode of drainage often successfully resorted to in the cellars of buildings here; and it has also been found very satisfactory in draining ground, upon a large scale, for agricultural purposes, many years ago, in England, as may be ascertained by reference to Johnson's able treatise upon *Drainage.*

Finally, having now discussed most of the subjects to which we had proposed to direct our attention, we may conclude by expressing the hope that some of the suggestions thrown out in the preceding report, may be found useful, and available, by the councils of Philadelphia, in improving the highways of their beautiful city.

By order of the Committee,

William Hamilton, Actuary.

*Philadelphia, June* 26*th,* 1843.

# Civil Engineering.

## *Experiments on Water-Wheels, having a vertical axis, called Turbines.* By ARTHUR MORIN, Captain of Artillery, Professor of Machinery in the School of Artillery, &c. &c. *Published at Metz, and Paris,* 1838.

(Translated from the French,* by ELLWOOD MORRIS, Civil Engineer.)

### I.

### *Of the different attempts made to improve Water-Wheels with vertical axes.*

Amongst the attempts made, for some years past, to improve hydraulic motors, the one most remarkable for its success, is that of M. Fourneyron, Civil Engineer, who, with that perseverance and firmness which leads to the end, has succeeded in giving to those wheels with vertical axes, which we call *turbines,* such forms and proportions as make them valuable motors in many departments of industry.

Wheels with vertical axes, have, for a long time, been used in the Pyrenees; and the mills of Toulouse, described by Bélidor, offer a remarkable example of their present application to the grinding of corn. But these wheels, where the water enters, and leaves, by the exterior circumference, after having acted on it merely by its concussion,† do not realize, in the most favorable circumstances, more than $\frac{35}{100}$ of the power expended by the motor. This is confirmed in the experiments made in 1821, by Messrs. Tardy and Piobert, officers of Artillery; many of which will be given further on. Other wheels of the same species, established at Metz, about three centuries ago, and some of which still exist, are far from producing as much effect as those of Toulouse, and from the observations made in 1825, by M. Poncelet, on their product in grinding corn, they do not realize more than $\frac{1}{15}$th of the power expended.

M. Navier, in his notes on Bélidor's Hydraulic Architecture, has given the theory of these wheels, as well as that of one kind of wheel with curved buckets, receiving the water without shock, and letting it escape without velocity, after descending from a certain height upon the wheel following the surface of the buckets; and he has also examined the case where the water entered nearer, or farther, from the axis, than it left it. This last theory, which applied to the numerous *reaction wheels* then known, or proposed, is equally applicable to the turbine of M. Fourneyron, whilst equating to zero the full length the water traveled upon the wheel.

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* Throughout *the text* of this translation, I have converted the French, into English measures; but in *the tables,* as they, in part, exhibit *ratios* which would not be altered, whilst the rest of the results tabulated, would have been much encumbered by fractions, it seemed more advisable *to retain* the French measures in these tabular statements. The *metre* is 39.371 *English inches.* The *kilogramme* 2.20485 *English pounds avoirdupois.* To *approximate* the details of any of the experiments, it will be found very convenient to call the *metre* 3 3-10 feet, and the *kilogramme* 2 1-5 pounds, neither of which values will be much in error, whilst their use very much abridges the labor of reduction to English measures.

† These are what we commonly call tub-mills.—Trans.

M. Poncelet in his lectures to the school of practice of the Artillery and Engineers, at Metz, had given, in 1826, a description and theory of a wheel with curved buckets, and a vertical axis, analogous to his wheel of the same species, of which the axis is horizontal, and which received the water without shock through many points of its exterior circumference, and allowed it to escape without velocity through the interior.

In 1833, M. Burdin, Engineer of Mines, proposed, and put to work, another species of wheels with a vertical axis, described in the Annals of Mines, third series, vol. iii, and has given to them the name of *Turbines*, which has since been applied to all wheels with vertical axes, capable of moving when immersed in the water, of the lower level.

But it was reserved for the perseverance of M. Fourneyron, who, since 1823, has occupied himself with this question, to attain the degree of perfection to which these wheels have been brought. In a memoir inserted in the Bulletin of the (French) Society for the Encouragement of National Industry, in the year 1833, this engineer has given a description of the wheel which he constructed, and for which he has secured a patent.

Respect for the rights so justly acquired by long labor, will prevent us from giving all the information which we have been able to collect, and of which we owe a part to the engineer, as to the forms and proportions of the wheels which we have submitted to experiment, and, consequently, we cannot compare the results of experiment with those of the theoretical formulas, in which these proportions enter as elements of calculation. But the point of most importance to the arts, is to know what duty we can require of this motor in various circumstances, and the results which we shall give on this particular, will, doubtless, appear sufficiently complete to warrant a positive conclusion respecting them.

## II.

### *Experiments on the Wheels of the Mills of Toulouse.*

Before reporting the results of experiments which I have lately made upon the *turbines* of M. Fourneyron, it will not be uninteresting to make known some of those, which, in 1821, had been observed by Messrs. Tardy and Piobert, on the different species of wheels of the mills of Toulouse; and from these we shall select only such as refer to the wheels which performed the best. We know* that the water is conveyed upon these wheels by a kind of pyramidal adjutage, called *the spigot*, and that after having acted by impulse upon the concave buckets of the wheel, it escapes below, and at the sides.† It was important to calculate with care, the expenditure of water made by this kind of orifice under given heads; or, in other words, to obtain its coefficient of expenditure.

These able officers determined this coefficient by observing with

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[*] Bélidor's Hydraulic Architecture, edition by M. Navier.

[†] These are a species of tub-wheels.—Trans.

care the time required to empty the basins forming the reservoir above the works, and they have found 0.900 for the mean value in this case. That determined, they were enabled to calculate the expenditure of water in *the spigot* for each height of level, as well as the quantity of *absolute work, or power,* developed by the motor.

As for the *useful effect,* it was measured by the aid of an apparatus similar to the *Brake, or Friction Dynamometer* which M. de Prony proposed and employed about the same time, but which was then unknown to them.

The theoretical formula of the *useful effect* of these wheels given by M. Navier, and by M. Poncelet is,

$$Pv = \frac{1000Q}{g}(V \text{ sin. } a - v \text{ sin. } c)\ v \text{ sin. } c.$$

in which we call, (in French measures)

P = The power transmitted by the water to the circumference described by the point of impact of the mean filament upon the wheel.

Q = The volume of water expended in *one second.*

$v$ = The velocity of the circumference of the point of impact of the water.

V = The velocity of the efficient water.

$a$ = The angle formed by the velocity V with the bucket at the point of impact of the water.

$c$ = The angle formed by the velocity $v$ with the bucket at the same point.

$g$ = 9.8088 metres. ($32\frac{1}{6}$ English feet.)

It follows from this formula that the maximum of effect must correspond to the relation,

$$v = \frac{V}{2 \text{ sin. } c.}$$

In the wheels of the mills of Toulouse, we have ordinarily, $a = 90°$, $c = 70°$, or sin. $a = 1$, sin. $c = 0.94$. For that of the New Mill,* on which the experiments were made which we are about to report, the point of impact of the mean filament was at a distance of $1\frac{74}{100}$ feet, from the axis of the wheel.

From these elements, it has been easy to form the following table, which contains the results of these experiments.

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* It must be borne in mind that this is a *tub-wheel,* actuated like all such, *by impact only.*—Trans.

EXPERIMENTS on one of the Wheels of the New Mill at Toulouse.

| No. of the exp. | *Weight* of water expended in one second. 1000Q | Tot'l fall. | Absolute *work* of the motor in one second. | *Velocity* of impact of the water on the wheel. V | *Velocity* of the point of impact of the water on wheel. *v* | Ratio of the velocities $\frac{v}{V}$ | *Useful effect* by theory. | *Useful effect* measured by the Friction Dynamometer, or *available work.* | Ratio of the *work available*: To the effect by theory. | Ratio of the *work available*: To the *absol'te work* of the motor. |
|---|---|---|---|---|---|---|---|---|---|---|
| | Kilog. | Mtrs. | Kilog. | Metres. | Metres. | | Kilog. | Kilog. | | |
| 1 | 341.1 | 4.39 | 1351 | 9.08 | 6.33 | 0.70 | 647 | 214 | 0.300 | 0.153 |
| 2 | 338.3 | 4.32 | 1318 | 9.00 | 6.76 | 0.75 | 581 | 211 | 0.370 | 0.162 |
| 3 | 302.8 | 4.26 | 1290 | 8.94 | 6.09 | 0.68 | 567 | 402 | 0.700 | 0.312 |
| 4 | 301.4 | 4.23 | 1275 | 8.91 | 5.76 | 0.65 | 581 | 408 | 0.700 | 0.320 |
| 5 | 299.0 | 4.17 | 1248 | 8.84 | 5.66 | 0.65 | 539 | 421 | 0.770 | 0.330 |
| 6 | 295.0 | 4.07 | 1201 | 8.73 | 5.76 | 0.62 | 539 | 352 | 0.650 | 0.293 |
| 7 | 294.0 | 4.04 | 1187 | 8.69 | 4.76 | 0.54 | 566 | 479 | 0.840 | 0.403 |
| 8 | 291.0 | 3.96 | 1151 | 8.60 | 4.99 | 0.58 | 543 | 451 | 0.830 | 0.393 |
| | | | | | | | | Mean, | 0.750 | 0.342 |

[In the above table the absolute work, or power, consumed by the motor, is calculated by multiplying together the second and third columns, or is, in fact, *the weight of water descending one metre in one second,* (and, excepting the first and second experiments, which have been rejected on account of some irregularity) the other columns sufficiently explain themselves.—Trans.]

## III.

### *Deductions from the results contained in the preceding table.*

An examination of this table shows that for the values of the velocity $v$ of the point of impact, or introduction, of the water on the wheel comprised between 54 and 68 *per cent.* of V, that of the effluent water, the ratio of the useful effect measured by the brake, to the useful effect by theory, is at an average equal to 75 per cent., and that, consequently, this useful effect will be represented within an eighth by the formula.

$$Pv = \frac{750Q}{g}(V \sin. a - v \sin. c)\, v \sin. c.$$

As for the ratio of the *available work,* measured by the brake, to the *absolute work, or power,* expended by the motor between the same limits, it has for a mean value,

0.342.*

which shows that these wheels return nearly as much (of the power expended) as those of good construction of which the planes of the buckets, and the axis, are horizontal, and which receive the water at the lower part (or, what we call, *undershot wheels.*—Tr.)

The relation,

$$v = \frac{V}{2 \sin. c}$$

which corresponds to the maximum of effect, gives, in the actual case, where $c = 0.94$

$$v = 0.55\,V,$$

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* About the same ratio of effect to power, as was determined, for *undershot wheels,* by Smeaton, and others.—Tr.

and experiment shows that the maximum of effect agrees with the values,

$$v = 0.54\text{ V, and } v = 0.58\text{ V},$$

which agrees with the results of theory.

Thus, the experiments of Messrs. Tardy and Piobert, enable us to determine *the useful effect* of a wheel having the buckets hollow, or scooped, and the axis vertical, on which the water acts by impulse within the ordinary limits of velocity, and show that the best of these wheels *do not return more than from* 35 *to* 40 *per cent. of the power expended.*

## IV.

### *Experiments on the Turbines of M. Fourneyron.*

*General description of the Turbines.*—Without entering into the details of the construction, it seems to us indispensible to preface the results of the experiments by a summary description of the machines to which this memoir applies; and we will select for example, *the turbine* established in the furnaces of Fraisans, referring for a more full description, to the memoirs which the inventor has presented to the (French) Society for the Encouragement of National Industry, and which are inserted in the Bulletin of that Society, for the year 1834. The two essential parts of *the turbines* of M. Fourneyron, are *the wheel*, or ring, with curved buckets, and *the sluice.*

The wheel, *a, a,* (fig. 1, 2, and 3,) is formed by an upper ring of strong sheet-iron, and by a ring below, cast in a single piece, with a concave base, which we call *the cap, c, c;* these two rings concentric with the axis of rotation, are placed horizontally, and joined together by the curved buckets, *d, d,* placed vertically, and also made of strong sheet-iron. The *cap* is fixed on the axis of rotation, to which it is firmly bound, and which it carries along in its rotary movement.

The *sluices* consist of a fixed bottom piece, or plate, *e, e,* connected with a hollow cast-iron pipe, which incloses the *main shaft* of the wheel, and is sustained, in the upper part, by wood work, or by supports of masonry. On this plate, *c, e,* rise vertically the curved guides, *f, f,* designed, as we shall show presently, to give to the water the proper direction for issuing from the orifices of emission.

A hollow, cylindrical casting, *g, g,* of which the position is parallel to the axis of rotation, is interposed between the wheel and the directing curves, or guides, and forms the *sluice-gate* properly so called. This cylinder moves concentric to another, *i, i,* which is fixed, and against which it rubs at its upper border, which is furnished with a shield of leather, that prevents the passage of the water when the annular-gate is let down upon the fixed plate, *e, e.* Whilst, on the contrary, if we raise the movable cylinder, or annular sluice-gate, *g, g,* the water runs out between its lower edge, and the plate, *e, e,* and can then enter within the wheel.

The curved guides, *f, f,* are placed in such a manner, that the water enters the buckets of the wheel without sensible shock, and the liquid, receiving on these, a corresponding motion, is directed on the side contrary to the general running motion of the wheel; it results from

Fig. 1.

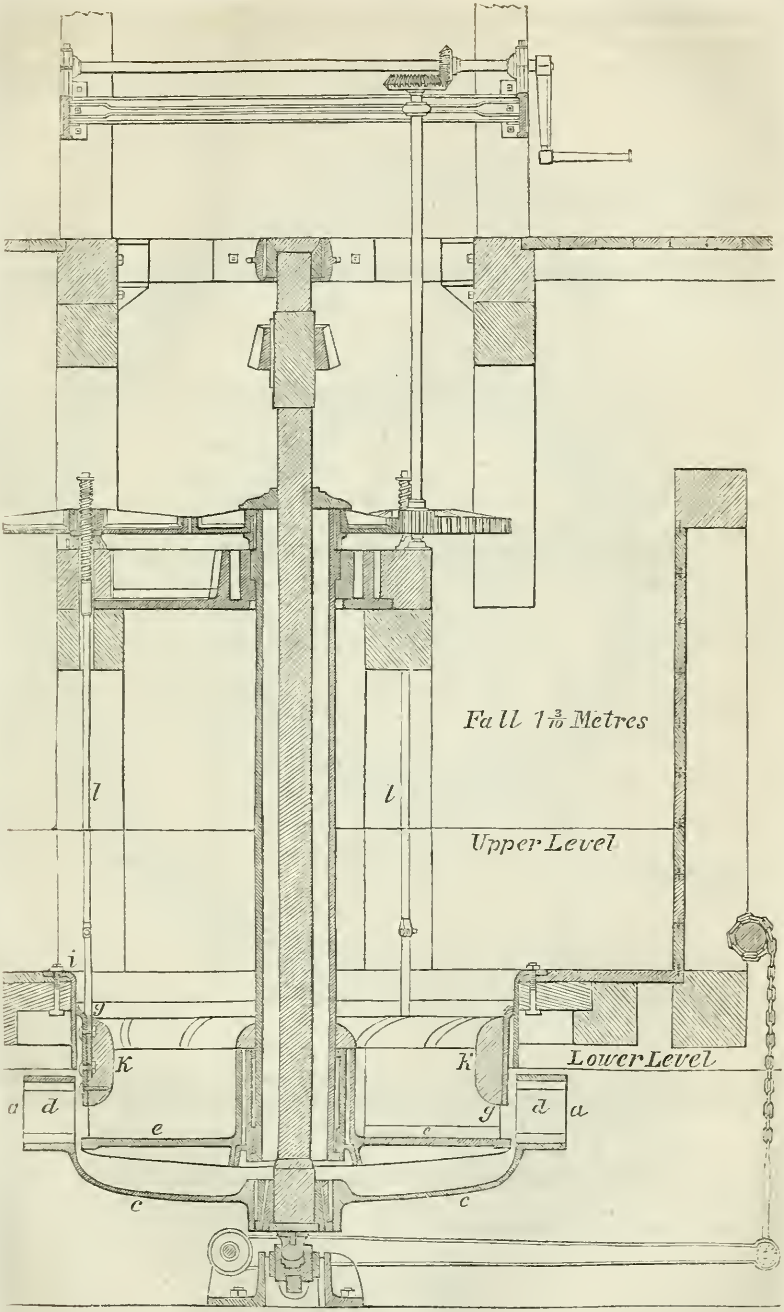
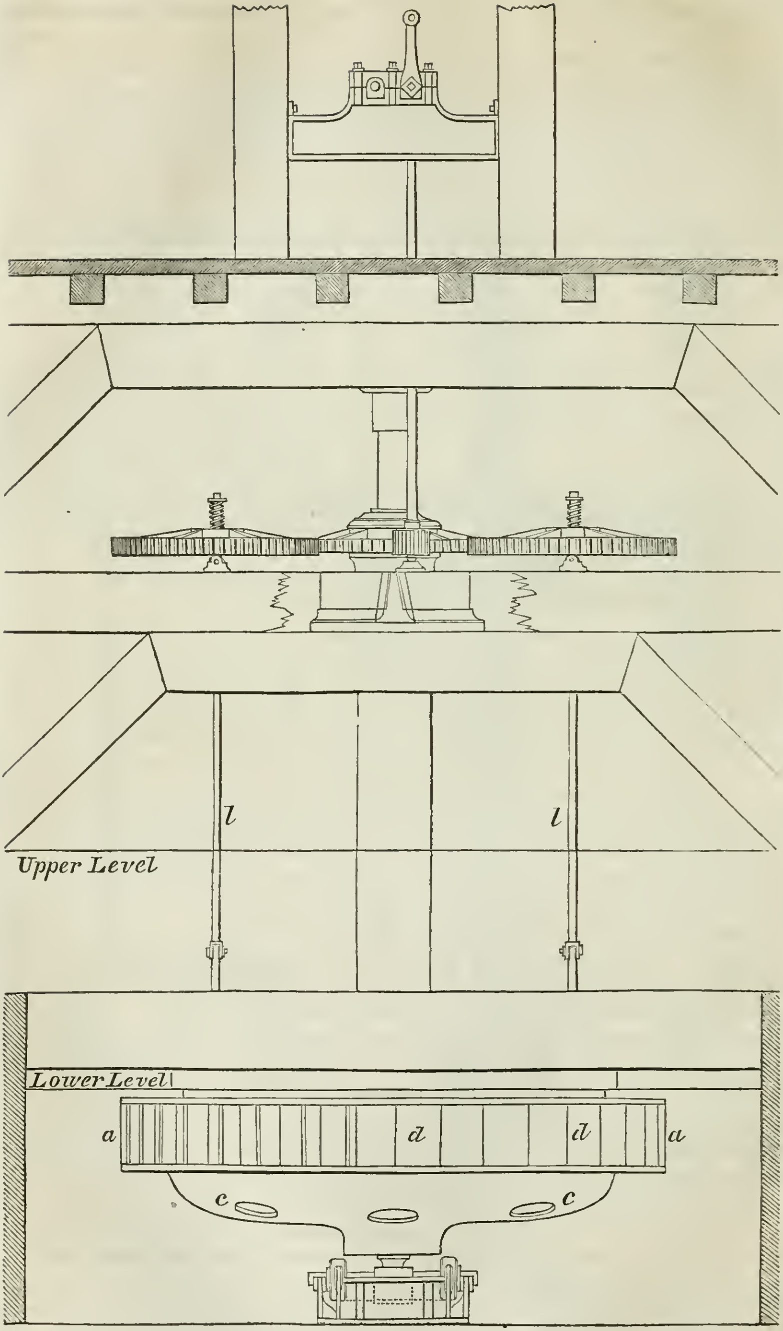
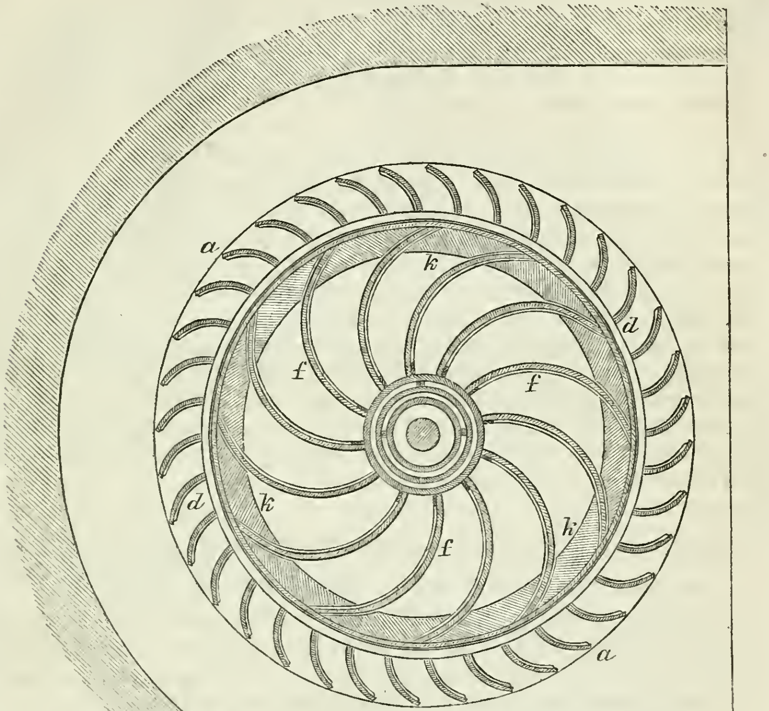

Fall 1$\frac{3}{10}$ Metres
l
l
Upper Level
i
g
K
K
Lower Level
a
d
d
a
g
e
e
c
c

Fig. 2.



the proportions adopted, and from the ratio established between the velocities, that the water enters nearly without shock, and issues with almost no velocity, which satisfies, as we know, the general condition of the maximum effect in hydraulic motors.

Fig. 3.



Scale of 25 millimetres to a metre.

The *wooden cushions*, *k*, *k*, fixed to the *sluice-gate*, and slipping between the curved guides, diminish by the rounded form of their lower parts, the effects of contraction, which is, in consequence, nearly destroyed, or at least, very much diminished, on the four sides of the opening.

The motion is transmitted to the *sluice-gate* by *three vertical stems*, *or rods, l, l,* cut into screws on their upper parts, and around which turn three pinions, all of the same diameter, which act as screw-nuts, and are put in motion by a wheel concentric with the vertical pipe which surrounds the *main shaft.* This ingenious arrangement insures parallelism of motion in the *sluice-gate.*

The *main shaft* passes through the hollow pipe, and has, on its upper part, a cog wheel, which transmits the motion into the interior of the works. At the lower part, this *main shaft* rests in a socket, which we can raise, as required, by the aid of a lever, and which, by an ingenious contrivance, is continually fed with oil, notwithstanding it is immersed in water. The lightness of these wheels, the constant supply of oil, which lubricates the rubbing surfaces, and the proximity of the water which keeps it from heating, remove all apprehension of the pivots wearing out, and the experience of many years demonstrates the excellence of the arrangement. The *turbines* producing a useful effect as great, in proportion to the power expended, when they are submerged, as when they are not, as we shall see further on. M. Fourneyron is in the habit of placing them, so that the level of the upper ring is the same as that of the lowest waters of summer; so that they, at all times, render the whole fall available, which is particularly advantageous at seasons when water is scarce.

As this brief description suffices for explaining the general action of the wheel, we pass on to the experimental results which constitute the chief object of this memoir.

## V.

## *Experiments on the Turbines of the Power Weaving Establishment of Moussay, near Senoues (Department of the Vosges.)*

*Summary description.*—There was established in 1836, in the village of Moussay, near Senoues, in the Department of the Vosges, a Power Weaving Establishment belonging to Messrs. Ed. Laurent & Co., which was put to work in the spring of 1837.

My duty having led me at this time into these works, I availed myself of it to request of the proprietors of this establishment, permission to make some experiments with this motor, from which to deduce its effect. My proposition was cordially received by these intelligent manufacturers, and they had the kindness to make all the arrangements necessary to mount the *brake, or friction dynamometer,* which I sent them. Their works, and their workmen, were liberally placed at our disposal. M. Fourneyron, in person, answered the invitation which was made him, to assist in the experiments; and it is with his aid, that they have been made. The manufacturers and engineers of the neighborhood came to witness, and lend us their assistance in the observations; *they were, consequently, made, and verified, by many persons.*

The motor of the works is a *turbine* of (0.85m.) $2\frac{79}{100}$ feet in exterior diameter, of which the vertical shaft transmits the motion directly to the lying shaft of the weaving mill, by means of a single beveled cog wheel. The water reaches the works by a canal of about (3 m.) $9\frac{84}{100}$ feet broad, and of a regular form, which conducts it into a prismatic reservoir of (5 m.) $16\frac{4}{10}$ feet broad, into which opens a large vertical pipe, communicating by a very short horizontal pipe, with the cylinder which contains the *sluices* of the *turbines*. This cylinder, in which the *sluice-gate* moves, is closed at its upper part, and traversed by the vertical shaft, of which the extremity is of such a height as to allow the lying shaft of the workshop to pass a little below the ceiling of the ground floor. In this way, although the total fall is about $26\frac{38}{100}$ feet, the transmission of the motion is made, in consequence, at any suitable height without hindrance.

## VI.

### *Arrangements adopted for the Experiments.*

The *brake, or friction dynamometer*, composed of a cast collar of (0.80 m.) $2\frac{62}{100}$ feet in diameter, turned on its outer circumference, was put on the same shaft as *the turbine*, and the lever, placed horizontally, was supported at its extremity by a cord (6 to 7 metres) $19\frac{60}{100}$ to $22\frac{97}{100}$ feet in length attached to the wood work, in order that it should not bend by its own weight. Over a fixed pulley, placed in a direction perpendicular to that which this lever should preserve whilst it was in equilibrium, passed a leather strap to which was suspended the box that contained the load of *the friction dynamometer*. To make sure that the lever and strap should preserve a perpendicular direction during the experiments, we suspended to a fixed point, a plumb line, below which the middle line of the lever was to be constantly maintained. The perpendicular let fall from the axis of the wheel on the direction of the strap, or the arms of the lever of the load was (2.505 m.) $8\frac{22}{100}$ feet in length.

To insure regularity of friction, we kept the cushion of the *friction dynamometer* constantly wet, in order to maintain the surfaces in the same state of humidity. In consequence of this precaution, the lever remained almost constantly below the vertical of the plumb line, without the oscillations exceeding the space of $\frac{13}{100}$ to $\frac{16}{100}$ of a foot, and without any blows having occasioned violent shocks, as commonly happened when the state of wetness, or oiliness, of the surfaces varied. It also resulted from this continual wetting, that we had not to employ grease in these experiments, and that the temperature of the surfaces in contact, was not elevated even in the greatest velocities, beyond moderate limits, and that to cool them, it was only necessary to continue wetting them during the occasional interruptions in passing from one series of experiments to another.

## VII.

### *Gauging of the volume of water expended.*

It was indispensable to give the utmost possible precision to the means employed for gauging the discharge of water through the orifices of the *turbines*, and it would have been troublesome to establish a stop-gate in the tail-race, which is arched, and of considerable depth, but the feeding-race offering, for that purpose, every facility, we placed at its end nearest to the works, a stop-gate with a waste-board of (2.682 m.) $8\frac{80}{100}$ feet wide, of which the vertical edges (of the overfall) distant (0.28 m.) $\frac{82}{100}$ of a foot from those of the canal, had sharp angles, as well as the sill (or edge of the waste-board,) which was (0.60 m.) $1\frac{97}{100}$ of a foot, at least, from the bottom of the canal. The water, consequently, did not reach the reservoir, or *trough*, leading to the wheel, until it had passed over the waste-board, the lower edge of which was never flooded by back water during the experiments.

This arrangement lost part of the fall, and reduced it for the experiments to about (7.50 m.) $24\frac{61}{100}$ feet, ($1\frac{77}{100}$ feet being lost in the clear fall over the waste-board, necessary to render it *a correct meter.*—Tr.) this loss was not productive of inconvenience for the experiments in general; but to be able to make some under the full fall which the works could employ, we subsequently dispensed with the stop-gate, and calculated the expenditure of water by the aid of observations, made during the first series of experiments, proceeding in the following manner.

## VIII.

### *Calculation of the volume of water discharged, based upon dimensions of the openings of the Turbines.*

The sum of all the shortest distances measured between the side of one curved guide, and the reverse of the adjacent one, being (0.689 m.) $2\frac{26}{100}$ feet, and the lift of the sluice-gate being known for each experiment; we thence easily deduce the sum of the areas of all the orifices by which the water issues, and, consequently, (knowing the head,) the theoretical discharge. By comparing this theoretical discharge with that calculated from the experiments made with the waste-board, we have deduced for each lift of the sluice-gate of the turbine, the coefficient of discharge belonging to the orifices.

For calculating the discharge of water made by the waste-board, we have used the formula,

$$Q = 0.405\,LH\sqrt{2gH}$$

where,

$Q$ = Quantity in cubic metres delivered per second.
$L$ = Length of the opening of the waste-board in metres.
$H$ = Depth of the edge below the surface of the reservoir in metres.

We resolved to adopt this formula, because, first, the sides, or borders, of the overfall, were at the distance of (0.25 m.) $\frac{82}{100}$ of a foot, at least, from those of the canal; second, the contraction was almost complete on three sides of the opening; and, third, some part of the furniture of the sluices allowed the escape of a little water which did not act upon the *turbine*. It seems to us, in consequence, that in adopting for the overfall the coefficient 0.405, we have estimated the discharge rather above, than below, the real value.

The following table contains the results of the comparison of the theoretical discharges computed from the dimensions of the orifices of the *turbine*, with the actual discharge calculated by the above formula.

Comparison of the actual with the theoretical Discharge made by the Orifices of the Turbine of Moussay.

| No. of experiments. | *Sum* of the Areas of the Openings. | *Charge* of water, or difference, of the upper and lower levels. | *Discharge of water in one second.* | | *Ratio* of the effective discharge, to the theoretical discharge, or coefficient of the discharge. |
|---|---|---|---|---|---|
| | | | Theoretical. | Actual. | |
| | Sq. Metres. | Metres. | Cub. Metres. | Cub. Metres. | |
| 1 | 0.0344 | 7.091 | 0.405 | 0.363 | 0.892 |
| 2 | 0.0337 | 7.056 | 0.396 | 0.362 | 0.914 |
| 3 | 0.0320 | 7.160 | 0.379 | 0.362 | 0.954 |
| 4 | 0.0344 | 7.255 | 0.411 | 0.372 | 0.904 |
| 5 | 0.0344 | 7.229 | 0.408 | 0.364 | 0.890 |
| 6 | 0.0344 | 7.131 | 0.407 | 0.363 | 0.892 |
| 7 | 0.0344 | 6.927 | 0.402 | 0.349 | 0.869 |
| 8 | 0.0324 | 7.127 | 0.383 | 0.373 | 0.975 |
| 9 | 0.0330 | 7.313 | 0.395 | 0.349 | 0.884 |
| 10 | 0.0330 | 7.239 | 0.393 | 0.360 | 0.915 |
| 11 | 0.0330 | 7.294 | 0.394 | 0.351 | 0.890 |
| 12 | 0.0330 | 7.134 | 0.390 | 0.351 | 0.900 |
| 13 | 0.0330 | 7.034 | 0.388 | 0.345 | 0.889 |
| 14 | 0.0330 | 7.854 | 0.382 | 0.348 | 0.910 |
| 15 | 0.0324 | 7.395 | 0.390 | 0.378 | 0.970 |
| 16 | 0.0351 | 7.375 | 0.422 | 0.389 | 0.915 |
| 17 | 0.0351 | 7.087 | 0.413 | 0.375 | 0.909 |
| 18 | 0.0344 | 6.911 | 0.401 | 0.366 | 0.910 |
| | | | | Mean, | 0.910 |
| 19 | 0.0517 | 7.278 | 0.617 | 0.523 | 0.848 |
| 20 | 0.0495 | 7.333 | 0.593 | 0.534 | 0.889 |
| 21 | 0.0544 | 7.105 | 0.640 | 0.540 | 0.842 |
| 22 | 0.0503 | 7.285 | 0.602 | 0.540 | 0.896 |
| 23 | 0.0503 | 7.150 | 0.596 | 0.515 | 0.864 |
| 24 | 0.0489 | 6.951 | 0.570 | 0.523 | 0.918 |
| 25 | 0.0489 | 6.986 | 0.571 | 0.520 | 0.910 |
| 26 | 0.0489 | 7.017 | 0.573 | 0.522 | 0.909 |
| 27 | 0.0489 | 7.019 | 0.574 | 0.512 | 0.891 |
| 28 | 0.0489 | 7.002 | 0.573 | 0.458 | 0.799 |
| 29 | 0.0489 | 6.994 | 0.572 | 0.512 | 0.894 |
| 30 | 0.0489 | 7.046 | 0.575 | 0.515 | 0.895 |
| | | | | Mean, | 0.880 |

## IX.

### *Deductions from the results contained in the preceding Table.*

We see by this table, that the coefficient of discharge, which, for a lift of the sluice-gate of (0.050 m.) $\frac{16}{100}$ of a foot, is at a mean equal to 0.910, reduces itself to 0.80, when the lift is made equal to (0.071, or 0.073 m.) $\frac{23}{100}$, or $\frac{24}{100}$, of a foot. This diminution is one consequence of the arrangement of the orifices of emission, which do not occasion much contraction either on the bottom, or on the vertical sides, and of which the upper side is furnished with a cushion of wood rounded on its inner angles, which gives its proper direction to the fluid vein before it reaches the orifice. For the smallest lifts of the sluice-gate, much inferior to the width of the cushion, the filaments issue horizontally, and do not undergo, at the sides, any other contraction than what proceeds from the convergence of the curved guides, so that this orifice is analogous to that of the conical, or pyramidal adjutages, (see page 235) and it explains how the coefficient of the discharge can become as great as 0.91.

In proportion as the sluice-gate is raised, the cushion having less influence on the direction of the fluid filaments, the contraction on the upper side of the orifice is not so completely annulled, and, therefore, the coefficient of discharge gradually diminishes with the lift of the *sluice-gate*, until that lift becomes equal to the height of the *turbine.*

We shall see farther on, by the observations made on the *turbine* of Mülback, that this induction is completely verified.

These observations accounting very well (as it seems to us) for the variations of the coefficient of discharge of these orifices, enable us to calculate by interpolation, the value of the coefficient of the discharge, in the cases where the lifts of the sluice were (0.86, and 0.107 m.) $\frac{28}{100}$, and $\frac{35}{100}$ of a foot, with which only we have worked, whilst omitting the gauge by the overfall, or waste-board.

In making the calculations, we have assumed, that within limits as narrow as those of our experiments, the decrease of the coefficient was proportional to the difference of the lifts of the *sluice-gates*, which evidently could not lead to any appreciable error. It is upon this basis, that we have adopted for the coefficient of the discharge corresponding to a lift of the gate of (0.086 m.) $\frac{28}{100}$ of a foot, the value of 0.86, and for a lift of (0.107 m.) $\frac{35}{100}$ of a foot the value 0.83.

(To be continued.)

## *Mr. Vignoles' Lectures on Civil Engineering, at the London University College.*

[Continued from Page 174.]

### SECOND COURSE—LECTURE XIV.—WORKING EXPENSES OF RAILWAYS.

Mr. Vignoles commenced by reminding the class, what he hoped they duly felt, that the great object he had in view during the present course, was to consider, in every bearing, the proportion between the cost and expenditure upon any work, as compared with the probable profitable returns. Although this consideration, and that of the good result of any such speculations, might be thought not to come strictly within the duties of an engineer, and, until of very late years, had been neglected, and, in some striking cases, absolutely repudiated, by eminent men, yet Mr. Vignoles was of opinion that it must ever be kept in view, and should absolutely form a branch of the engineer's study, for he ought to feel that any works he may be called on to construct, should not only be such as will reflect credit on him as a professional man, for design, arrangement, and execution, but, as the Professor had often urged, such as, in this commercial country, where private enterprize and speculation attempts, and effects so much, will, by their success, prove the accuracy of his judgment, and his capacity, as an adviser, to lead spirited undertakers into future operations of the same kind. In short, that the success of an engineer depends, perhaps, more on the beneficial results of his works to the proprietors, as commercial speculations, than on his own masterly conquest by art over natural difficulties. But the engineer should further look at this subject in a higher point of view, and consider that all unprofitable expenditure is so much waste of the resources of a country, and that, of all professions in society, his is the one most called upon to direct the laying out of large sums on what may truly be considered national objects, for the judicious and beneficial results whereof he is responsible, and, consequently, whereon his reputation must ultimately depend. Referring to an expression in a late lecture, the Professor observed, that he by no means intended to represent that it was not necessary, in the construction of railways, to reduce the natural undulations of a country to uniform inclinations, but that it was to be maturely considered at what cost such advantage is to be acquired, keeping constantly in view a comparison of this cost with the working expenses of a line more or less perfect. It was the investigation of these *working expenses* that was now to be entered on. In proceeding to do this, Mr. Vignoles observed that he considered it by far the best way to reduce to a mileage, not only their gross sum, but also each of the items, these being again subdivided as far as possible. By a "mileage," he understood the result arising from dividing the periodical amount of the expenses by the total number of miles run by locomotive engines *with trains after them.* The Professor insisted that this was the proper way, and gave a number of reasons for his opinion, and for not at all considering the expenses with reference to any proportion they might form of the gross receipts—the two sources of income and expenditure being perfectly independent of each other; and Mr. Vignoles further thought this mileage comparison was the only one from which correct results could be drawn, and whereby materials and experience might be collected, so as to result in the practical benefit of companies being able, before long, to enter into contracts for most of the items of expenditure at given rates. Some companies had already contracted with each other for the supply of locomotive power, carriages, &c., at a mileage; the maintainance of the way was now almost universally paid for by the lineal mile of rail, and he had no doubt, but that, after a little more experience, other of the working expenses of railways would form subjects of such a kind of contract.

Mr. Vignoles then proceeded to enumerate the general heads of these expenses, viz., 1, *locomotive power*, subdivided into drivers' wages, fuel, oil, hemp, &c., ordinary repairs, water, and fuel stations, reserve fund; 2, *carriages;* 3, *maintenance of line;* 4, *police;* 5, *conducting traffic and stations;* 6, *rates and taxes;* 7, *government duty;* 8, *miscellaneous charges;* 9, *management.* These were the proper items, exclusive of interest on loans, which, although to be deducted before a dividend could be made, of course, formed no part of the positive working expenses of a railway. The Professor then went into a minute analysis of these several items, as actually disbursed on certain railways of various lengths, and, particularly, of various gradients, explaining the reasons of excess, or of diminution, in one, or other, item on the respective lines, exhibiting also comparative tables, and making many valuable observations upon obtaining the best attention, and greatest economy from the servants of a public company, by instituting premiums graduated in proportion to the diminution of annual working expenses.

*Locomotive power.*—In considering this item, Mr. Vignoles showed, from an average of a number of lines, where the arrangements were properly established, and the railway had been long enough at work to have got all matters systematically arranged, the subdivision per mile per train might be taken as follows—viz., wages, 2*d.;* fuel, 4*d.;* oil, hemp, &c., 1*d.;* making 7*d.* per mile as the mere cost of motion, exclusive of repairs of any kind. This might be considered as applicable to an average of six or eight carriages per train. Heavier trains only came occasionally in the course of the 24 hours, and unless upon lines having exceedingly favorable gradients, auxiliary engines were then applied, the cost and mileage of which being included in the annual accounts, the above rate of calculation would still apply. On railways not having a very considerable traffic, the number of carriages, on the average, were fewer than above stated, and the engine and tender might be fairly taken as constituting half the gross load of each train. The items of wages, and oil, hemp, &c., would not materially vary on different lines, except, perhaps, the first, or on short lines with very great traffic, with quarter, or half-hour, trains, such as the London and Greenwich Railway, the Dublin and Kingstown, &c. The fuel would be a variable quantity, but it would rarely exceed 6*d.* Next must be taken the ordinary repairs, and the Professor stated that in no case was the old adage of "a stitch in time" so applicable, as in a constant vigilance, and daily inspection, and remedy, of the smallest defect in locomotive engines. A plentiful stock of engines of the very best materials and workmanship, and an efficient and roomy repairing establishment, though somewhat costly at first, would be found to be the means of keeping down the expense of repairs to a low figure. The amount of this item spread over a year's working appeared to average, on well regulated lines, about 7*d.* to 8*d.* per mile; some instances had been as low as 6*d.* The expense of water and fuel stations varied from ¼*d.* to ½*d.* per mile. The reserve fund was an arbitrary charge; Mr. Vignoles assumed that about 10 to 15 per cent. on the ordinary repairs would be sufficient—say 1½*d.* Thus it would seem that the total cost of locomotive power ought to be about 15*d.* or 16*d.* per mile per train. In some instances it had been reduced so low as 1*s.*; in others this amount had swelled to 18*d.*, and even up to 2*s.*

Mr. Vignoles then analyzed the other heads of the working expenses—viz., carriages, which he seemed to consider an expensive item, varying from 4*d.* to 6*d.* per mile per train—say from ½*d.* to 1*d.* per carriage per mile, including the various descriptions of vehicles for passenger traffic. The maintenance of the railway varied most remarkably, from 2*d.* per mile per train (which had been the cost on the Dublin and Kingstown Railway and was now even lower, and Mr. Vignoles believed that on the Greenwich Railway this was also a small item, since they had replaced their stone blocks by timber supports), up to 1*s.* per mile per train, which was the cost on several lines; but, on a railway with the upper works properly constructed, he thought that 6*d.* to 8*d.* per mile per train ought to keep a double road in good order, including a reserve, or depreciation, fund for renewing the iron rails—a contingency that should by no means be lost sight of. The Professor here made a long digression on this item, as to how much of the cost should be assigned to atmospheric causes, and all collateral and contingent circumstances; how much to the mere dislocation of the upper works; and how much to the positive wear and tear of the iron; and pointed out some remarkable instances of saving in maintenance, where the longitudinal timber bearings had been adopted. The charge of police varied from 1*d.* to 6*d.* per mile per train, according to the vigilance exercised; in placing 2*d.* per mile as an average, it was to be considered only as an approximation. Conducting the traffic and stations was an item that did not seem to differ much on the various lines; for the passenger department it appeared to be about 5*d.* Local rates and taxes would, of course, vary materially; the poor rate formed a serious charge on all railways; this item was indirectly contingent on the actual profits of the company; it appeared, however, to be seldom less than 3*d.* per mile per train. Government duty had heretofore been computed at ⅛*d.* per passenger per mile—henceforth it was to be calculated at 5 per cent. on the gross receipts for passengers only. This would, of course, make greater discrepancies; still, as the new duty on the gross was estimated to be equivalent to the old duty, an account might be obtained if the number of passengers per train were known. Assuming this number to average forty, taking all the railways of the United Kingdom, the government duty might be estimated at 5*d.* per mile per train. Taking a mean of four or five railways, the miscellaneous expenses were found to be about 2*d.*, and the management about 3*d.* per mile per train. Now, to make a summary of all these, which was, however, to be taken generally, and, of course, liable to be effected in the details, but was still interesting to be submitted in a popular form, and might be useful as giving a comprehensive view of the system;

*Abstract of the average working expenses of a railway per mile per train.*

| | *s.* | *d.* |
|---|---|---|
| Locomotive power—viz., wages, 2*d.;* fuel, 4*d.;* oil, hemp, &c., 1*d.;* ordinary repairs, 7*d.;* water and fuel stations, ½*d.;* reserve fund, 1½., | 1 | 4 |
| Carriages, | 0 | 4 |
| Maintenance of line, | 0 | 8 |
| Carried over, | 2 | 4 |

| | s. | d. |
|---|---|---|
| Brought over, - - - - - - - | 2 | 4 |
| Police, - - - - - - - - - | 0 | 2 |
| Conducting traffic and stations, - - - - - | 0 | 5 |
| Local rates and taxes, - - - - - - - | 0 | 3 |
| Government duty on passengers, - - - - | 0 | 5 |
| Miscellaneous expenses, - - - - - | 0 | 2 |
| Management, - - - - - - - - | 0 | 3 |
| Total, - - - - - - | 4 | 0 |

Mr. Vignoles did not, by any means, pretend that this was other than a probable approximation. Some lines had been worked at a lower rate per mile per train, including all the above expenses; for example, the latest accounts of the North Union Railway, show the cost to have been only 3*s.* 4*d.*, not including any funds for reserve. The Professor himself thought that 3*s.* was a fair sum, exclusive of taxes and duty, which, however, together form a large proportion of the expense. On the other hand, there were instances in which the expenses had gone up to 5*s.* per mile per train. He considered it would be a great public benefit if all railway companies, in their reports, would give fuller details of the working expenses, and state the number of miles run *by trains.* Some few Boards set a very good example in this respect. This was sometimes done for locomotive power, but the miles should only be computed as actually run with the trains, and not to include the various extra distances passed over in manœuvres, piloting, signals, &c., which though necessary, were not part of the actual mileage of trains.

The Professor then drew the attention of the class to the fact, that the locomotive power formed about one-third of the gross expense, and of that one-half only is likely to be affected by the gradient, or load, being only one-sixth of the whole of the working expenses, which was but a small item upon which a saving was to be made, to justify a railway being constructed theoretically perfect, unless the traffic was likely to be continued, regular, and very heavy. He further observed, that though he had proposed, for the sake of an easier comparison, to reduce all the items of the working expenses of a railway to a mileage per train, it was manifest that a considerable addition to the number of trains daily, and, of course, to the number of miles run, would very materially affect the locomotive power only. The taxes would be contingent on the receipts; and all the other items would be increased but in a very small degree, on the annual totals, by an increase in the number of the trains, with a carriage or two less at a time. It was important to remember this, as it affected greatly the question of laying out railways. Mr. Vignoles insisted that the extension of railways in England, especially in remote districts, would not be carried into effect until this subject had been more closely analyzed, and had become better understood. Looking at the practical working of the Newcastle and Carlisle, the North Union, the Manchester and Leeds, the Sheffield and Manchester, as far as opened, and other lines, all having very heavy gradients, and contrasting their working expenses with those of lines whose inclinations were much more favorable, the average cost per train per mile did not vary greatly. Lines which had been formed at a cost of from £50,000 to £60,000 per mile, a large portion of which was to obtain perfect gradients, seemed to require little less to work them than lines costing only one-third to one-half that sum. It is true they might be able to carry heavier trains, and did so carry them occasionally, but the average was very nearly what had been stated, and, besides, the public were best accommodated by lighter trains going more frequently. The Professor said, he could only hope that his arguments would draw attention to the subject, and that when, after the analysis of the cost of all the railways had been brought out in the way shown in his last lecture, and that of the working expenses, as in the present one, materials would be obtained for the solution of the problem, of what must be the rule for constructing lines of passenger railways hereafter.

(To be continued.)

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FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

## *On the Injury done to Roads by the Passage of Carriages.*

An able report* has lately been made to the French Chamber of Peers, by the Minister of Public Works, M. Teste, on the maximum load which carriages should be allowed to draw on the roads constructed by the government. In contains, as its basis, a clear and minute account of a series of experiments, performed by M. Morin, during a period of several years, to ascertain the manner in which the injury done to roads, by the passage of vehicles, depends upon the dimensions of those vehicles, and on the loads which they carry. These experiments are not yet generally known, and they seem so valuable, on many accounts, to both the engineer, and the machinist, that some extracts from the report of M. Teste, may be acceptable to our readers.

But besides the experimental results themselves, and apart from the subject upon which they directly bear, there is one point suggested by the reasoning of M. Morin, of so great interest, as to warrant an extended notice. This is the relation between the deterioration of roads, and the resistance to the motion of carriages, or, to state it in a more general form, between the injury, and the contemporaneous friction. The evident advantage in almost every department of the arts, of the determination of this relation, is sufficiently obvious; but the inquiry assumes a graver importance from the singular and violent contradictions which it discloses between the received laws of friction, and the facts which have been observed. Whenever such differences occur, it is natural to wish to reconcile, or explain, them, and this becomes absolutely necessary in a question of such immediate, and practical concernment as that of friction. As the limits, however, of a prefatory notice will not admit of a complete solution of this problem, we can do scarcely more than submit to the consideration of engineers, a purely theoretical formula, which both explains the anomalies hitherto observed in the laws governing the attrition of bodies, and contains the relation between the deterioration, and the friction, of which we have spoken.

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* Addition à la Séance de Mercredi, 10 Mai. Moniteur 14 Mai, 1843.

It is, in the first place, evident that the injury done to any body by the action upon it of any other body moving over it, must be proportional to the force, or power, expended in producing it. This force is of two kinds—one, a part, or a function. of the force of gravity, or the weight, of the moving body; the other, the force necessary to overcome the resistance in the direction of the motion, occasioned by the inertia and cohesion of the opposing particles of the stationary body, and to tear them off, or separate them. Representing the first force by $fP$, and the second by R, we shall have for the expression of the injury, $M\ (fP+R)$, M being a coefficient depending upon the nature of the rubbing surface. But if we should adopt a very common opinion as to the cause of the friction, and believe it to be solely the opposition of the projecting particles of the surface, upon which any body moves, so that these particles must be broken off, and cast aside, in order to admit of motion, we shall evidently have, as a formula, for the friction, $F=R$. Now, it is perfectly plain, that whenever M and $fP$ are constant, any increase, or decrease, in the injury, must take place in the term R; R, therefore, will, in this case, vary when the injury varies, and, consequently, the friction which is equal to R, will vary when the injury does. But the experiments of M. Morin, in 1837, will be seen, hereafter, to prove that the injury increases when the velocity increases; the friction then should likewise increase with the velocity, and yet M. Morin has shown, from his experiments in 1831, reported in the Memoirs of the Academy of Sciences, for 1833, and since in this Journal,* that the friction does not change with any alteration in the velocity.

Here, then, occurs that violent contradiction between theory and experience, to which we have alluded—a contradiction only to be explained by the insufficiency of the one, or the incompleteness and inaccuracy of the other. It is most natural to suppose that the theory is defective, and that some other cause concurs in producing friction besides the mere resistance of the particles of the rubbing surfaces. If this is actually the case, the expression for the friction will no longer be R, but of the form $X+R$, and then it is evident that an increase in the value of R so great as to cause a very marked variation in the injury, may only occasion an almost imperceptible increase in the friction, so that it might easily be overlooked by experimenters.

To discover, then, this additional cause, or, perhaps, causes, and to derive from thence a complete theoretical equation for friction, let us suppose that the body A, is drawn over the body B; that the friction is to be measured by the force of traction continually necessary to maintain an uniform motion; and, finally, that B is of such hardness, or consistence, that A cannot sink farther than its own height into B. The definition given to the friction, is the one generally used, and the last supposition is made solely to simplify the question. Now, there may be, and there usually are, with the substances in common use, three different causes of friction, or, of the resistance to motion—one already mentioned, the direct opposition of the particles of the body B, which A, in its motion, tends to break off, or plough up, or divide, in order to move; the second, the resistance occasioned by the shocks which the roughnesses of B must produce, if they do not give way to A; and the third, that disclosed by the elegant hypothesis of Euler, (Mem. Berl. Acad., 1748, p. 125,) an hypothesis, which, like most of the works of that great mathematician, has been too much neglected by subsequent theorists. We shall consider these separate causes in the inverse order to that in which they are named.

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* Vol. x; 2nd, series, p. 285.

The conjecture of Euler is somewhat similar to that of M. Parent, but much more simple and natural. It consists solely in supposing that the little projections, or roughnesses, which exist on the surface of every body, form a complete succession of inclined planes, up which one body moving over another must be forced. Now, it is perfectly evident, that more power will be needed to draw a weight up an inclination, than along a perfectly level surface, and this additional power required, is, according to Euler, the whole of the friction. To make this clearer, imagine the plane B, to be placed horizontally, and made perfectly smooth and hard, (for, although this is not possible in reality, it is so in imagination,) and let the body A be drawn over it: it will at once be seen that there can be no resistance to the motion, and that any, the least, power will be sufficient to move it. Imagine again, that B, although still remaining perfectly hard, is not entirely smooth, but covered with a succession of minute, and similar elevations, or inclined planes. The whole resistance now will amount to the force necessary to compel A, resting itself upon small projections of its own, to ascend any one of these little inclinations of B.

The power, then, required to move A forward, or the resistance, or the force of traction, or the friction, for these are all equal in quantity, will depend, in the first place, upon the weight of A, or upon P; in the second, upon the nature and form of these minute elevations. It may, therefore, be represented by C.P, in which expression, C is a variable function of the nature of the substance of the body B. As we shall hereafter see that this expression does not represent the whole of the friction in all cases, nor, indeed, in general, we may designate the portion which it does represent, by F′, whence results the equation,

$$F' = C.P. \qquad (1)$$

When the body A has thus ascended one of the inclinations, the little projections of its own, on which it is supported, have to descend into the hollow between the similar projections of B, in the same way that cog-teeth fit into each other. In the course of this descent the force of gravity, and the velocity combined, drive the projections of A against those of B, and this shock acting obliquely to the direction of the motion, impedes the progress of A, and constitutes, therefore, a part of the resistance. It may be represented by D.P.$v$, where $v$ is the velocity of A and D, a variable function of the nature of the body B, and of the angle which the line of draught makes with the plane of B. We have, therefore, for the effect of the second cause of friction,

$$F'' = D.P.v. \qquad (2)$$

As the hypothesis of Euler, however, and the conclusions deduced from it, imply a degree of hardness in the body B, sufficient to enable its little projections to preserve their form against both the pressure of the imposed weight, and the shocks which they suffer, this hypothesis will not be sufficient to account for the resistance when B is composed of any yielding substance. To discover an expression for the additional friction produced in this case, we must resort to the supposition of another cause—the cause, in fact, which was mentioned at the outset.

Imagine, then, the plane B, to be composed of matter not possessing cohesion enough to prevent the body A from sinking partly into it. According to this hypothesis, A, in its motion, will tear up, and either carry alon gwith it, or cast aside, some part of B, and the power expended in doing this, is evidently equal to that part of the friction which is due to the direct opposition of the particles. In order to estimate its amount,

Let $h$ represent the force of cohesion of the material of B, or the weight which B can support upon a square foot without yielding.
$d$, the depth, or thickness, of A.
$b$, the breadth.
$mb$, the length.
$v$, the velocity.
$P'$ the weight pressing upon a square foot of the lower surface of A.

Then the friction arising from the cause just mentioned, will be proportioned:

First, to the depth to which A will sink into B. Let this depth be $x$, and $x$ will depend upon the weight which causes the sinking. The weight on a square foot effective for this purpose, is the difference between the actual pressure $P'$, and the quantity $h$, which B is capable of sustaining by virtue of its hardness; it is therefore, $P'-h$. If there was no other force to oppose this, and if $P'$ were greater than $h$, the body A would sink entirely through B. But every substance in nature becomes more compact by compression, so as to be able to support weights indefinitely great. Suppose, therefore, that B increases in density, and hardness, in such a manner that its supporting power at any small depth as $x$, may be represented by $h+(fh)x^{z}$, $(fh)$ being a function of $h$, and $^{z}$, the exponent of the power designated by the law of the increase. We shall now have $h+(fh)x^{z} = P'$, or $x = \sqrt[z]{\frac{P'-h.}{fh}}$ Introducing the value of $P'$, or $\frac{P}{m.b.b.}$ the equation becomes,

$$x = \left(\frac{P - m.b^{2}.h}{m.b^{2}.fh}\right)^{\frac{1}{z}}.$$

In the second place, the resistance, or the friction, will be proportional to the force of cohesion $h$ of the particles, which the body A has to tear apart in its motion forward.

In the third place, the resistance would vary exactly with the breadth $b$, (since the greater the breadth, the more particles must be torn up, and pushed forward) if it were not for one remarkable circumstance. When A has separated in its motion, the molecules of B, it generally throws them on one side, as a plough would do, else it would have to force along in front of itself, a strip extending the entire length of B. Now it is evident that the broader the front surface of A is, the more difficulty will there be in throwing the molecules completely to one side, and the longer will it take to do it, so that the number of particles which have to be carried along in front of A, before being thrown aside will increase, and, therefore, the resistance will increase with an increase in the breadth. The resistance is not then exactly proportioned to the first power of the breadth, but to something more, to $b^{1+n}$, $b^{n}$, representing the increase in the resistance arising from the circumstance just mentioned. In air, $n$ has been found to be about $\frac{15}{100}$; in water, about $\frac{2}{10}$. In sand, which is a semi-fluid, it may, perhaps, be called $\frac{1}{5}$.

In the fourth place, the resistance varies with the first power of the velocity, when the definition for friction, which we have adopted, is used; for the greater the velocity of A, the greater likewise will be the force with which it strikes the particles of B, the greater, consequently, the reaction upon A.

Uniting these separate modes of variation, that part of the resistance, or friction, which is the result of the cause which we are now considering, will be represented by $E.x.h.b.^{1+n}\,v$, E being a coefficient to be determined for each substance by experiment. Substituting the value of $x$, and reducing, we shall have the equation,

$$F''' = E.\left(\frac{P - m.b.^{2}h}{fh.mb^{2-z-nz}}\right)^{\frac{1}{z}} h.v.$$

And making $z=1$, which is the most natural supposition at small depths.

$$F''' = E.\left(\frac{P - m.b.^{2}h}{fh.m.b^{1-n}}\right). h.v. \qquad (3)$$

This equation represents the amount of friction derived from the direct opposition of the particles, to a force tending to break them apart, and plough them up. But in no substance, with which we are acquainted, and especially in no granular material, will this be the only cause of resistance to motion. For, suppose that the body A has sunk to any determinate depth in B, it will then rest upon a bed of minute molecular projections, or grains, or inclined planes, similar to those over which it would have to pass upon the surface of B, if it did not sink. Besides, therefore, the force necessary to push a bulk of matter before it proportional to the depth sunk, two additional forces must be employed, or expended—one, to draw A up these little inclinations; the other, to supply the power lost by the shocks. Each of these forces is the measure of an additional portion of the friction, the first, as we have seen, being represented by F′, and the second, by F″, so that the hypothesis of Euler, and the common one, are not contradictory, but equally probable, and they should be considered together, and not separately, when we would account for the effects of friction. We ought, then, to make the entire resistance from friction the compound, or sum, of these three resistances, which we have analyzed, and to establish for the final equation,

$$F = F' + F'' + F''' = C.P. + D.P.v + \frac{E.\,(P - m.b^2 h).\,h.\,v.}{fh.\ m.b^{\,1-n}} \qquad (4)$$

It would exceed the limits of this article, to compare this equation in all points with experimental results, or to enter into the complex analytical investigation necessary to determine the values of the variable coefficients, C. D and E. It is sufficient that these contain no terms which can materially affect the conclusions which we wish, at present, to draw.

I. When $h = P'$, or $P = m.b^2 h$, that is, when the cohesion, or hardness, of the surface of the body B, is sufficient to support the weight P without any alteration in its particles, the third term will vanish, as it is natural to expect, and then $F = C.P + D.P.v$, or rather inasmuch as on a comparatively smooth surface, and with small velocities, $D.P.v$ will be very small, with relation to the first term, we shall find very nearly $F = C.P$, the second member of which contains no factor of the surface, or the velocity. The friction, is, then, proportional simply to the pressure, and this theoretical conclusion is abundantly confirmed by the experiments of Coulomb and M. Morin, with *hard* and *smooth* substances.

II. When $h = o$, inasmuch as the variable coefficients C and D must contain $h$ as an implicit factor, the three terms vanish, and $F = o$, as in a vacuum, and approximately in the air.

III. When the quantity $m.b^2 h$ holds, as in all yielding substances, an intermediate value between P and $o$, the friction will increase when the velocity increases, and will decrease with the breadth, or the surface; and this has been very clearly shown to be the case, by the experiments of Vince, Coulomb, Parent, Rennie, and those of Morin in 1838, upon bodies possessing little cohesion in proportion to the pressure. This conclusion, fortified by so many proofs, cannot be invalidated by the experiments of M. Morin in 1831, which were all made with comparatively *unyielding* materials. It is to be noticed, however, that the friction is not exactly proportional to the velocity, but to an expression of the form $1 + Mv$, where

$$M = \left[ D.P + \frac{E(P - m.b.^2 h).\,h}{fh.\ m.\ b^{\,1-n}} \right] \div CP.$$

Hence, it is evident, that M must be very large, or that CP must be very small, compared with the value which $F'' + F'''$ obtains at a velocity of one foot per second, in order that the friction may be considered proportional to the velocity. But it is easily seen that with hard bodies CP, is *greater* than the value of $F''+F'''$ referred to, and therefore, it is nowise surprising that experimenters upon unyielding substances, have, of late, considered the velocity to have no effect upon the friction.

Having thus seen that the equation (4) is not only probable from theoretical considerations, but also confirmed in its most essential parts by experience, let us attempt to derive from it the relation which the injury done to any body B, by the motion of another body A over it, bears to the friction produced at the same time between A and B, and to this end, let us resume the reasoning which was employed at the commencement. An expression was there found for the injury, such that if we represent it by I, we shall have the equation, $I=M.(fP+R)$, or since, according to the definition there given for R, $F'''=R$, the above equation will become,

$$I=M.(fP+F''') \qquad (5)$$

and substituting the value of $F'''$ in terms of F, $F'$ and $F''$,

$$I=M.(fP+F-[F'+F'']). \qquad (6)$$

If the values of M, $F'$ and $F''$, and the nature of the function of P can be determined for the substances in common use, we can likewise obtain the value of the injury I, directly from the measurement of the friction F, so that the wear of machinery, and the deterioration of roads and railways, may thus be estimated in a simple and expeditious manner. As the problem, however, under this general form, is somewhat too complicated for our present limits, let us consider the equation (5) as it becomes when the proper value of $F'''$ is inserted, that is, when

$$I=M.\left[fP+\frac{E.(P-m.b^2h).h.v.}{fh.m.b^{1-n}}\right]$$

It will be seen by a little reflection, that $\frac{P-m.b^2h}{fh}$ is a factor of $fP$, so that this equation becomes,

$$I=M.\frac{(P-m.b.^2h).}{fh}\left[X+\frac{E.h\,v}{m.b^{1-n}}\right] \qquad (7)$$

X representing the other factor of $fP$. The injury, therefore, decreases when the surface $m.b^2$, or the breadth $b$ increases, although not in exact proportion; it also increases with the velocity, and when X is 1, or of a value much smaller than $E.h$ (as it must always be), the injury may be considered as increasing proportionally to the velocity. These conclusions, it will be seen, are confirmed by the experiments of M. Morin.

The formulas thus far introduced, are applicable only to the case of prismatic bodies resting upon a plane surface; when the lower surface of the rubbing body is perceptibly curved, as in the case of wheels, some modifications must be made in the expressions for the friction and the injury, which may be briefly noticed. Suppose, in the first place, that the wheel does not roll, but is simply dragged along. The first term of the friction $F'$, will not be altered, but the second and third, $F''$ and $F'''$, will receive a change; for the direction and force of the shock, represented by $F''$, will vary with the curvature of the striking body, and the coefficient D must, therefore, vary from the same cause, and, with regard to the third term $F'''$, $m$ is a function of the curvature of the increase of density $fh$, and of the weight upon a square foot $P'$, so that it is only when all these remain the same, that $F'''$ is unaltered.

Imagine, again, that the wheel is rolling. In this case, the modifications, noticed above, are still necessary, and with them some others, of which we need only, for the purpose of determining the deterioration of roads, specify that which takes place in the third term. It is not difficult to see that the part of the force of traction which corresponds to $F'''$, must vary inversely with the diameter of the wheel, for this force acts at the axletree, while $F'''$ acts at the circumference, so that the force referred to, is equal to $\frac{F'''}{\frac{1}{2}d}$. But this explanation does not at all imply that the real friction at the circumference, and, consequently, the injury is diminished by an increase in the diameter, although a little consideration of the subject will show that this is the fact. If a wheel was so low that the resistance from obstacles upon the road, should be in a direction passing through the centre of the axle; that is, if the centre should not be higher than the obstacles, no motion could take place, unless the wheel broke down what opposed it; but if we suppose that the radius of the wheel is increased, and the line of draught, thus made, to pass above the line of resistance, both a rotary and a forward movement would take place—the wheel, that is, would roll up, and surmount the obstacle. This effect would be more likely to occur, as the radius of the wheel was greater, and since it evidently amounts to changing the crushing and tearing action, represented by $F'''$, into the motion up inclined planes, represented by $F'$ and $F''$, it must cause a decrease in $F'''$, proportioned to the probability of its existence, proportioned, that is, to $\frac{1}{2}d$, or one-half of the diameter of the wheel. The greater, therefore, this diameter, the less will $F'''$ be in the case of rolling wheels, and the equation (5) will become $I = M. \left[ fP + \frac{F'''}{\frac{1}{2}d} \right]$, whence, as before,

$$I = M. \frac{(P—m.b.^2h)}{fh} \left[ \frac{X + H.h\,v}{d.m.b^{1-n}} \right] \qquad (8)$$

H, in this expression, is equal to 2E.

It has already been remarked that $m$ is a function of the curvature, and, therefore, must change when the diameter changes. If we suppose it to increase with the first power of the diameter, it may be represented by $sd$, $s$ being a coefficient depending upon the other causes of variation. By introducing this value of $m$, by making $X = 1$, and the exponent $n = \frac{1}{5}$, or $n—1 = \frac{4}{5}$ (as is the case in sand or gravel), the equation (8) will become,

$$I = \frac{M.(P—sd.b.^2h]}{fh}. \left( \frac{1 + H.h.v}{sd^2.b^{\frac{4}{5}}} \right) \qquad (9)$$

This is, then, an approximate formula for the injury done to roads by the passage of carriages. The most important of the consequences which may be deduced from it, seem to be the following: The injury *increases* with the load P, and the velocity $v$, although not in exact proportion to the increase of those quantities. The injury also *decreases* when the breadth of the wheel $b$, or when the diameter $d$, increases, although not in exact proportion.

These conclusions may be drawn from the simple inspection of the equation. Some of the less obvious results, are, that when several carriages travel, one exactly behind the other, those behind do scarcely any injury, in comparison with the foremost; that when several carriages are loaded with weights proportioned to the breadth of their wheels, those with the widest wheels will do the most injury; and, finally, that when several carriages are loaded with equal weights, the injury will not decrease as fast as the breadth of the wheels. All these theoretical conclusions are confirmed by the experiments of M. Morin, and this coincidence may be considered as a proof of the correctness of the formula. The accuracy, however, of the particular equations, which have been given, is not of so much importance as the soundness of the general method by which they are constructed. This method consists simply in the union of all the causes which can, in any way, contribute to the production of a certain effect, and the combination of the partial effects, which each of the causes would of itself produce, into one expression representing the real, or complete, effect. It is, in fact, an application of the theory of probabilities, the variable functions C, D and E. $\frac{(P-h)}{fh}$ representing, respectively, the probability that $F'$, $F''$, or $F'''$, will exist, or that the different causes of friction, which occasion those terms, will really act. How far this method may be employed with advantage in physical researches, is a question worthy of some consideration.

The foregoing observations and formulas, will, perhaps, do something to show the importance, in many points of view, of the series of experiments undertaken by M. Morin, by order of the Minister of Public Works, and may serve to clear up some points which those experiments left doubtful. The actual demonstrations of experience, however, are more quickly comprehended, and more easily applied, than any abstract conclusions,) and practical men, therefore, will like to see the results of investigations, conducted with the ability and care which distinguish all M. Morin's inquiries.

"Towards the end of the year 1838," says M. Teste in his report, "and when the last draught of a law upon the regulation of the transport of goods, already adopted in the Chamber of Peers, was about to be discussed, in the committee appointed by that of Deputies, an officer of Artillery, commissioned by the Minister of War, with the execution of some experiments on the traction of carriages, M. Arthur Morin presented a memoir, upon this question, to the Academy of Sciences. In that work, the author arrives at many conclusions, relative to the action exerted by vehicles upon roads, which are the only ones with which we shall here occupy ourselves." [These conclusions were, in brief, the following: "The injuries produced by carriages upon roads, are as much greater as the wheels are smaller; (which is not altogether accurate) the resistance upon paved, or solid, macadamized roads is nearly independent of the breadth of the tire; upon such roads, also, even when they are in a very good state, the shocks occasioned by the inequalities of the ground, produce a loss of the velocity, and, consequently, an increase of the resistance, as much more remarkable, as the velocity is greater, and the carriage less elastic;" and, finally, "carriages without springs, going at a walk, injure macadamized roads more than carriages with springs, going at a trot."]

"Such were the principal conclusions as to the action of carriages upon roads contained in that memoir, which, when submitted to the judgment of the Academy of Sciences, had obtained the approbation of that illustrious Society, upon the report of a committee composed of M. Arago, Poncelet, and Coriolis, reporter. That work necessarily attracted all the attention of the administration of roads and bridges, as well as that of the committee of the Chamber of Deputies. The discussion, therefore, of the report of that committee, was adjourned to allow time to repeat and verify the results, and the conclusions announced.

"To arrive at this verification, the Minister of Public Works asked of his colleague, the Minister of War, that the author of the experiments should be attached to his department, for the special purpose of executing such others as should be judged necessary, according to a programme which had been requested from him, and a special committee of engineers of roads and bridges was charged with examining the successive results of the experiments.

"The experiments commenced in the month of March, 1839; their principal end being to discover the influence of the loads, of the breadth of the tires of the wheels, of the diameter, of the velocity, and of the springs, regard being had to the destructive effects produced upon gravel roads, the village of Courbevoie, (whence depart many solid macadamized roads, made of a siliceous gravel from the basin of the Seine, having all a thickness of 12 to 14 inches, at least, and having been put in a good state of repair,) was selected as a central point for the experiments. The general system of experimenting adopted, was the following: The carriages, whose injurious effects were to be compared, were drawn over portions of the same road, taken at the beginning in the same state. Each of them had its particular track, over which it ran, going and returning constantly upon the same route, in order to accumulate and multiply the injury to the road. When the weather was too dry, the tracks were watered, in order to maintain them at the same relative degree of moisture. Each day the committee noted the number of passages executed by the carriages, and took care, in each series, to regulate this number, so as to make the same weight, including the carriages, pass over each of the tracks.

"When, after the transportation of the same weight upon the tracks to be compared, (each of which was always more than one hundred metres, per 109 yards in length,) the injuries were thought to be sufficiently increased to give approximate results, the intensity of the force of traction of the carriages upon each track, was measured with very accurate dynamometers, and by the comparison of the different intensities observed with each other, and with that of the traction upon the untouched road, the absolute and relative increase of the traction corresponding to the injury produced, could be appreciated. These trials were repeated many times, and when it was at last judged that the injuries were sufficiently advanced to allow a conclusion to be deduced, the experiments on the traction were repeated for the last time; the state of the different tracks was noticed, and transversal sections of the ruts were drawn, in order to compare them with the primitive state of the road.

To these three means of comparison, there was afterwards added the sum of the quantities of materials employed in the repair of the road, after the removal of the mud and the dust, which gave nearly the empty space formed by the ruts, or the amount of the materials of the road ground up and separated. Thus, the committee had four methods of observation for comparison, in order to appreciate the destructive effect produced by the carriages—the account of the state of the ruts—the drawings of the transversal sections—the measurement of the intensity of the force of traction—and the amount of the materials employed in the repair. The results of these four methods have always presented a satisfactory agreement worthy of inspiring confidence in the conclusions which have been deduced from them.

" In order to determine the part which each one of the elements in this complicated question played, care was taken to separate it from the others. Thus, when the committee wished to compare the effects of different breadths of the wheels, they employed carriages exactly alike as respects the diameter, and all other circumstances except the breadth of the wheels. In the same way they determined separately the influence of the diameter of the velocity, and of the springs.

" Each of the series of experiments required not less than 20 or 25 consecutive days, and it was not until the end of the year 1839, that the results could be discussed. The principal experiments, and the conclusions which their author has deduced from them, are the following:

" Three wagons, mounted each upon four wheels of the same diameter, but with tires whose breadths were 6.9, 4.5, and 2.4 inches, respectively, were loaded proportionally to the breadths, in the ratio of 550 pounds for one inch. After the passage of about 8000 tons over each of the tracks, it was found that the track of the carriage with the largest tires was the most injured, while that of the carriage with tires 4.5 inches broad, was also seen to be more affected than that of the carriage with tires of 2.4 inches in breadth. Hence, it was concluded that, 'when the loads are proportional to the breadth of the wheels, the carriages with the broadest wheels, cause the most injury to the road.'

" Another series of experiments, executed with the same carriages, loaded with *equal* weights, including the carriages themselves, showed that, although it is incontestible, that wagons with narrow tires of 2.4 inches, do more harm to macadamized roads, than those with large tires, still there is little difference between the injuries caused by those with tires of 4.5 inches, and of 6.9 inches in breadth. This has confirmed the opinion announced in 1838, that there is not any remarkable advantage for the preservation of roads, in employing wheels more than 4.7 inches broad.

"The same wagons mounted upon wheels having a common breadth of 4.5 ins., and of the different diameters 2 ft. 10 ins.—3 ft. 11 ins.—6 ft. 8 ins., and loaded each with the same weight, 10,846 pounds, were drawn over three tracks upon the same road. After the transport of 9,741 tons, it was found that the wagon with the small wheels of 2 ft. 10 ins. in diameter, had produced the most considerable injuries, and that the wagon whose wheels were 6 ft. 8 ins., had only occasioned a trifling rubbing. Hence, came this conclusion, 'that wheels of a small diameter by the effect of separation of the particles of the road *(désagrégation)*, which they produce, do more harm than wheels of a great diameter.'

"Two post wagons exactly alike, and hung upon eight springs, were loaded, first with 13,200 lbs., and afterwards with 11,500 lbs. only. One of them whose springs had been wedged up, was drawn at a walk: the other, whose springs remained free, was conducted at a trot with the velocity of 8¾ miles per hour. After the transportation of about 4,534 tons upon each of the tracks of these wagons, it was found that the one ran over by the wagon on springs, was a little less injured than that of the wagon without springs, which went at a walk. Hence, came the conclusion, 'that carriages with springs going at a trot, can bear equal loads to those of carriages without springs, proceeding at a walk, without occasioning greater injury to a macadamized road than the latter.' The results of the experiments, also, having been the same from the commencement, when the road was in a good state, to the end, when the tracks had become very bad, the foregoing conclusion can be applied to all cases."

[This experiment is, perhaps, the most interesting and important of all which M. Morin made, because it is extremely difficult to determine *á priori*, the extent of the influence of springs, and we have hitherto had very few data by which we could form a judgment on this point. It will not be difficult now to find an approximate value for this influence. Let $x$ represent the ratio of the force required to draw a carriage with springs, to that necessary to move at the same speed, the same carriage without springs. Then, if we suppose the speed with which the wagon, whose springs were wedged up in the foregoing experiment, proceeded, to have been 3¾ miles per hour, that part of its force of traction represented by $\frac{F'''}{\frac{1}{2}d}$ (eq. 8) was

$$\frac{15.\mathrm{H}.(\mathrm{P}-m.b^2.h).h}{4\ldots\ldots fh.d.m.b^{1-n}},$$

and when mounted on springs, and going at the rate of 8¾ miles per hour, its force of traction $\frac{F_1'''}{\frac{1}{2}d}$ would, consequently, be,

$$\frac{35}{4}.\frac{4}{15}.\frac{15}{4}.\frac{H.(P-m.b.^2h).h.}{fh.\,d.\,m.b^{1-n}}X.$$

But since, according to the result of the experiment, $I=I'$, or

$$M.\left(fP+\frac{F'''}{\frac{1}{2}d}\right)=M.\left(fP+\frac{F_1'''}{\frac{1}{2}d}\right)$$

we must have $F'''=F_1'''$, and by substituting the values of these quantities just found, and reducing, it will appear that $x$ is equal to $\frac{15}{35}$, or $\frac{3}{7}$. This, however, only represents the influence of springs in reducing the amount of $F'''$. To determine the entire effect upon the whole friction, we must observe that $F''$ is the only remaining part that is affected by the elasticity of the carriage, and that upon iron rails, $F'''$ may be considered as vanishing, so that we there have $F=F'+F''$. Let us, also, suppose that these two quantities $F'$ and $F''$, are equal to each other in this case, and further, that $F'$, $F''$ and $F'''$, upon a macadamized road, are also equal to each other. Now, it was found by M. Pambour, (Treatise on Locomotives, ch. iii, sec. 8,) that upon railroads $x=\frac{97}{100}$, whence it follows, that if F represent the friction of a railway carriage without springs, $\frac{97}{100}F=F'+\frac{94}{100}F''$. represents the friction with springs, and that $\frac{94}{100}$ is the factor by which $F''$ must be multiplied to show the effect of the use of springs. We shall find, therefore, that the resistance with springs in the case of macadamized roads, which we are especially considering, will be equal to $Fy$, or $F'+\frac{94}{100}F''+\frac{3}{7}\frac{F'''}{\frac{1}{2}d}$, whence $y=\frac{79}{100}$, and, therefore, by the addition of springs, the friction, or force of traction, necessary to draw a given load, is reduced to 79 per cent. of what it would have been without them. The suppositions which have been made to arrive at this conclusion, are, in some respects, arbitrary, although they are scarcely unnatural, but, from a more general consideration of this question, it appears probable that the value of $y$ is never greater than $\frac{1}{2}$, and it may, in practice, be always estimated as exceeding $\frac{2}{3}$. If it should amount, in any case, to this last quantity, the use of springs would allow the load to be increased one-third, whence it may be seen of what importance a complete investigation of the most effectual mode of applying, and fashioning springs, would be to the machinist, and the engineer.]

"A final series of experiments executed in 1839, has had as its object, to ascertain the influence of the division of loads upon the injury. A wagon with four wheels, each 6.5 inches in breadth, and weighing 17,457 lbs., or about 650 lbs. on an inch of the breadth of the wheels—a cart with two wheels 6.5 inches broad, weighing 11,000 lbs., or 846 lbs., on an inch of the breadth—and eight smaller wagons with tires 2.4 inches broad, weighing each 3,960 lbs., or about 412 lbs. per inch of the breadth of the sustaining surface, and going in a train, one exactly behind the other, were drawn upon three tracks, taken in the same condition at the outset, and kept constantly wet and muddy.

After the transportation of 6,862 tons, it was evident that the four wagons drawn together, had caused much less injury than the other vehicles, and that the large wagon had done less harm than the cart, whose ruts had become so bad that it was almost impossible to draw it over the road.

"Hence, resulted the following conclusions. I. The division of loads upon many axletrees, or vehicles, is essentially favorable to the preservation of the roads. II. The wagons with tires 2.4 inches in breadth, going in trains, do less harm to the roads than large wagons and carts, carrying loads hitherto admitted. III. The load of 11,000 lbs. for a cart, and that of 17,457 lbs. for a four-wheeled waggon, (which amounts to about 10,406 lbs. on the hind-axletree) are so great as to occasion very remarkable injuries to the roads, and there is good reason to lay it down as a rule, that the load of carts, and that upon the hind-axletree of wagons, ought never to exceed much 8,800 lbs.

"Such were the most remarkable and important results of the experiments executed in 1839, by the order of the administration." Besides these experiments, of which a full account has here been given, to show the admirable manner in which they were conducted, another series was commenced in April, 1841, and continued until December, in the same year. As this series, however, was merely corroborative of those already described, and elicited no facts, or general laws, but what can be drawn from the others, it would be useless to translate more of M. Teste's report.

The experimental data which M. Morin has obtained, and, perhaps, the theoretical conclusions, which have been sketched in the foregoing pages, may do something to clear up, not only the question of the deterioration of roads, but the still more difficult problem of the laws of friction. So remarkable, and, apparently, irreconcilable, have been the variances between theory and experience, with regard to these laws, that mathematicians seem to have given up their investigation in despair, and Mr. Whewell has gone so far as to assert, that friction depends upon a distinct quality of matter, not yet discovered, and that it is vain to attempt to derive it from any of those common properties, with which we have hitherto had to do. Perhaps there is no good reason for so broad an assertion; perhaps more satisfactory results might have been obtained, by viewing the subject in a different light. It would, indeed, be idle to suppose, that the formulas, which have been given in this article, contain all that is necessary for a complete solution, or that they satisfy all the conditions of this intricate question. To do this would require a more subtle and careful analysis, than that here attempted; but the general method which has been employed, and the agreement of the equations, with the results of experiments, may not be unworthy of notice.

W.

# Architecture.

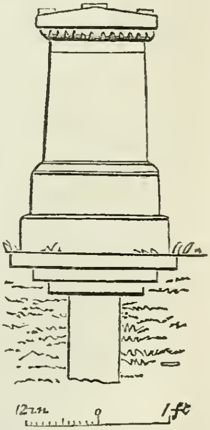
## *The Principles of Landscape-Gardening and of Landscape-Architecture applied to the laying out of Public Cemeteries and the Improvement of Churchyards; including Observations on the Working and General Management of Cemeteries and Burial-Grounds.* By J. C. Loudon, F. L. S., H. S., &c.

### II. THE LAYING OUT, BUILDING, AND PLANTING OF CEMETERIES.

(Continued from page 187.)

*Sepulchral monuments*, whether mausoleums (which is a term only applied to the most sumptuous description of tombs), square tombs, ledger-stones with inscriptions, sarcophagi, pedestals, vases, urns, columns, obelisks, pillars, crosses, &c., to have the appearance of security and permanence, ought to exhibit two features; they ought to be perfectly erect, or perpendicular, and they ought to rise from an architectural base. These features it is easy to exhibit when the monument is newly put up, but to continue them, even for a year, it is necessary to have a foundation of masonry under ground, as well as a basement above it; and, in order that this foundation may be permanently secure, it must be as deep as the adjoining grave, or graves. In the case of vaults and brick graves, this secure foundation is furnished by the structure itself; but in the case of common earth graves, a foundation requires to be built up, and the problem is how to effect this in a manner at once secure and economical. In most cemeteries and churchyards, and even in Père la Chaise, and Kensal Green, the greater part of the monuments have no other foundation than the moved soil, and only comparatively few are placed on the firm soil. The consequence of this is, that, in two or three years after the monuments are put up, they are found leaning to one side; or, if they are composed of several pieces, they are seen with joints rent, and conveying ideas the very reverse of permanence. Our remedy for the evil, is, two brick, or stone, piers at the head of each grave, carried up from the bottom, and from 9 in. to 2 ft. square, according to the depth. The two piers should be brought up at the same time, and tied together by building in pieces of iron hoop; and, when within a short distance of the surface, they should be joined by a semi-circular arch, or carried up to the surface, and connected by a lintel, which may be the visible base of the head-stone. Where a pedestal ornament of any kind, not more than 18 ins. on the side, was to be put up, one pillar 18 ins. square might suffice; or, when there was no danger of the ground being moved, even a 9-inch pier, as in fig. 5, would keep the pedestal from sinking. Where two graves

Fig. 5.



were built end to end, or side by side, three pillars would serve for both graves: and where four graves were to be made side by side, and end to end, three pillars would suffice; or, in effect, two pillars, as shown in fig. 6, the two half-pillars, at *a* and *b* not occupied, being charged by the builder to the cemetery, which would have a right to sell them to those who made adjoining interments. These pillars may be built in a few hours, by having beforehand portions of them prepared with brick and cement, in the manner familiar to every builder; or, in stone or slate countries, underground props of these materials might be formed; nor do we see any objection to cast-iron underground props. Where permanent endurance was the main object, we would not use cast-iron monuments; as it is next to impossible to prevent the rust from appearing through the paint, and scaling off so as to destroy, first the inscription, and next the body of the monument. In some of the London cemeteries, temporary labels of wood, having on them the number of the grave, or of the interment, and sometimes the name of the party interred, are used; and where economy is an object, and durability to the extent of a generation considered sufficient, we do not see any objection to the use of cast-iron tallies, such as fig. 7; their lower extremities being so fixed to a piece of wood, as to prevent them from being pulled out, while a circular disk, resting on two plain tiles, or bricks, will prevent them from sinking.

Fig. 6.

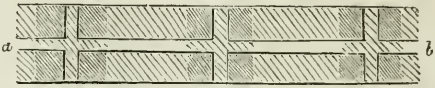
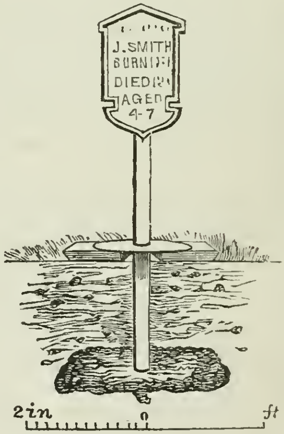


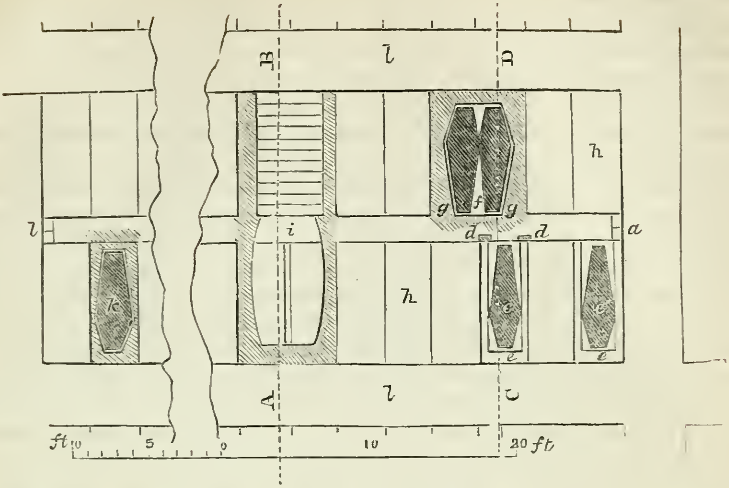
Fig. 7.



It is in order to supply room for head monuments that we have reserved a space of 2 feet in width between each double row of graves, as shown in the ground plan, fig. 8. In this figure, *a*, *b*, is the space between the two lines of graves, commencing and ending with a number-stone; *c*, *c*, are common graves with coffins, with piers for head-stones at *d*, *d*, and spaces for foot-stones, a foot in width, at *e*, *e*; *f*, is a brick grave with two coffins inserted, the head-stone to be placed between *g*, *g*, and *d*; *h*, *h*, are spaces left for common graves, brick graves, or, by occupying four divisions, for vaults; *i*, a vault for two coffins in width, occupying four divisions; *k*, a vault for one coffin in width, occupying one division; *l*, *l*, the green alleys between the double rows of grave beds, or panels.

When it is in contemplation to have a double line of brick graves, or to fill up a cemetery regularly, without allowing a choice to the purchasers, as in the cemeteries of the Jews, then a foundation wall 2 ft. in width, might be regularly carried up along the middle space, between the lines of graves, from one end of the line to the other.

Fig. 8.

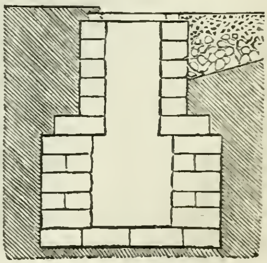


*Cenotaphs*, as every one knows, are monuments put up to the memory of persons who are interred somewhere else. They commonly consist of tablets with inscriptions, medallions, busts, basso-relievos, or other sculptural objects, and are very fit ornaments for affixing to walls under cover, or protected by architectural projections, such as those furnished by a chapel, a cemetery veranda, a boundary wall, or a structure erected on purpose, as is not unfrequent in the French and German cemeteries.

*Walls*, when used as the boundary of a cemetery, and built of brick, may be carried up hollow, which will be a considerable saving of material, and render all piers unnecessary, unless for effect, or, in the case of cemeteries laid out in imaginary squares, the piers which are to contain the stones having the letters and numbers.

The *main conveying-drains* of a cemetery, if built of brick, should be barrel-shaped, in the usual manner; but, if of stone, the bottom should be laid with flag-stone, and the same description of stone should be used for the covering. *Main collecting-drains* may be formed by semi-cylindrical tiles placed on flat tiles in the bottom, and small stones placed over them to within a foot, or less, of the surface of the ground. *Surface collecting-drains* may be 20 inches deep, formed like the last, with tiles at the bottom, and carried up to the surface with small gravel, finishing with coarse sand; and, when these drains are in the green alleys, grass may be sown over them. When at the sides of the gravel walks, or roads, they ought to communicate with surface gratings at regular distances; and immediately under each grating, there ought to be a pit 1 ft. square, and 2 feet

Fig. 9.



deep to retain the sand carried in by the water, (fig. 9,) this sand being taken out once a year. Where the roads and walks are laid with asphalte, gratings of this kind will be more necessary than when they are made of gravel, as a certain proportion of the water always sinks through the latter material, but none through the former.

The *furniture*, or tools, implements, and temporary structures, of large and complete cemeteries, consists of picks, spades, shovels, levers, rakes, scrapers, brooms; a rope and pulley, or block and tackle, to be used with a triangle; planks, ladders, grave-boards, dumcrafts, grave-platforms, grave-boxes, grave-moulds, wheelbarrows, buckets for raising soil, a frame for supporting canvas, or a tarpaulin over a grave while being dug during rain; and a temporary structure, consisting of a floor of boards, or wooden grating, with three sides, and a roof of canvas, rendered waterproof by paint, for the protection of the clergyman while reading the service at the grave; with another structure, of a larger size, for sheltering both the clergymen and the mourners.

The *grave-box* consists of a bottom and sides, the latter readily separating from the former; and its use is to hold the soil dug out of the grave, till the grave is ready to have the soil returned to it. From one to four boxes are required for a grave, according to its dimensions. Their use is two-fold: to preserve the soil from mixing with the grass, from which it is difficult afterwards to separate it so entirely as not to leave a quantity of it entangled among its leaves; and to return the earth in the most rapid manner to the grave. The box, before receiving the earth from the grave, is placed alongside, and raised up in a sloping position; the earth is thrown into it; and as soon as the coffin is lowered, the grave-diggers loosen and take out the side of the box next the grave, when the soil immediately begins to drop out, while, by raising the other side of the box, the whole is returned to the grave, and not a particle of earth is to be seen on the surface of the grass. This box was first used by Mr. Lamb, an undertaker in Leith, and is now in general use in the burial-grounds about Edinburgh. There ought to be a number of such boxes for every cemetery; and it would be an improvement to place them on low wheels, say those on the side which is to be next the grave of 6 inches in diameter, and those on the opposite side of double that height. This, while it would save the trouble of propping up the boxes, would also enable the grave-diggers to wheel them away, one after another, as fast as they were filled, and, when the grave was completed, to leave it quite free on every side, for the approach of mourners, who would in this case walk on the turf, instead of walking on loose earth, or planks. This result is sometimes obtained by throwing all the excavated soil into wheelbarrows, and removing these to a short distance, there to stand till the coffin is deposited. Either of these modes is much better than the common one of throwing up the soil on each side of the grave, and obliging the coffin-bearers to clamber over it. As the grave-boxes are readily taken to pieces, they can be stowed away, in sheds, or tool-houses, in little space.

A *clergyman's shelter* is unnecessary where a tarpaulin, or a movable shed, is used over the grave; but, where this is not the case, it may be formed of five pieces, viz., a flooring of boards, or, to prevent slipping when the boards are wet, as well as to render the floor lighter, of wooden grating, raised one or two steps above the general surface, in order to give the reader of the service a more commanding position. To this floor three sides, each consisting of a frame of canvas, are readily fixed by means of studs in the lower rails of the sides, dropping into holes in the framework of the bottom; and they are as readily connected together by hooks dropping into eyes. The roof-piece, which ought to be raised a little in the middle to throw off the rain, can readily be dropped on four iron bolts, fixed in the upper ends of the styles of the sides. The whole may be painted black; and, when not in use, it should be taken to pieces, and kept in a dry, airy situation. A tent, or movable structure, to cover, not only the clergymen, but the mourners assembled, either during rainy weather, or hot sunshine, might be formed without difficulty, and at no great expense. The framework might be light iron rods; and the canvas might be so arranged as to be drawn up and let down, like the awnings to tulip beds, or the outside gauze shades to hot-houses.

## Mechanics and Chemistry.

### *Iron-Founding.—From the Glasgow Pract. Mech. & Eng. Mag.*

(Continued from Page 197.)

### Section II.

Amongst the great variety of work denominated green-sand moulding, much and varied contrivance is displayed in the structure of the moulds. In particular, the management of cores is a matter of very considerable importance, and the malformation of them is a prolific source of failure in the production of sound castings.

Cores are especially useful for forming vacancies in castings. Their forms may be long, and proportionally small in diameter, or winding and otherwise intricate; and seeing that they are necessarily surrounded by the iron when cast, they ought to have, as much as may be, the qualities of firmness of substance, and openness of pores. Cores, as has already been stated in the first paper, are commonly composed of rock sand, and sea sand. The former, having a proportion of clay in its composition to which it owes its powerful cohesiveness, when dried, serves very well as a material for short cores that rest in the green sand at both ends, as open communication with it is thus afforded for the free escape of the air in the interstices of the cores. But when rock sand is used for cores of considerable length, (which, of course, are surrounded on all sides by the iron, except the small imbedded portions at the extremities, by which alone the air can escape,) it requires to be moderated by the admixture of free sand as a counteractant to the clay. The clay communicates the necessary cohesiveness to the material of the core: the sand, on the contrary, loose and open, renders it less binding, and more porous.

Free sand alone is also employed in the construction of confined cores, that they may afterwards be easily extracted, as the sand has naturally no power of cohesion. Wanting cohesiveness, it must be tempered to a proper consistency by the addition of clay and water, yest, or the refuse of the pease-meal, used for light, flat moulding purposes. In the use of the last material, it must be accurately proportioned to the sand with which it is mixed. The clay-water is, in ordinary cases, made use of as a cement, and the yest only in very particular circumstances. For large compact masses of core, the common green sand may be used, as illustrated in both examples, given in our last communication.

The longer cores are stiffened by iron wires, and small rods which are bent, if necessary, to the form of the cores. These rods are enveloped in the core in the progress of its formation, and are afterwards extracted from the casting. The cores of considerable length are pierced longitudinally by wires for the escape of the air; or, in cases in which this is impracticable on account of bends, or angles in the core, a piece of string is laid in the sand, alongside the stiffening wires, which is afterwards drawn out when the core is dry, leaving its perforation behind it.

With all these precautions for securing the strength of cores, and for the all-important purpose of letting off the air, blown holes do occur at times in castings, formed by the air thrown off the cores into the iron.

When the bearings of cores at the extremities are considered unfit for steadying them, they are further sustained by steeples stuck into the sand at several places in their length. These are simply nails with broad, flat heads, and several of them being set into the sand, and projecting above it just as much as the thickness of metal, the core is placed upon them, and sustained steadily in its place; the steeples are, of course, buried in the casting, and the points of them projecting outside, are chipped off in the course of dressing it. Chaplets* are also used to bear up cores having plane surfaces.

Fig. 1.

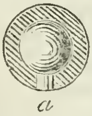


Fig. 2.

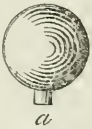


Fig. 3.

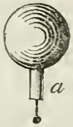
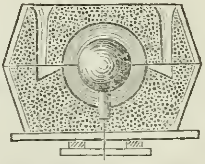


Fig. 4.



An excellent example of the use of free-sand cores is found in the construction of bomb-shell mouldings. The form of a bomb-shell, it may be stated, is simply a hollow sphere of cast-iron, having one small round hole as a passage to the interior, termed the fuse-hole, as in the annexed sectional view, (fig. 1,) in which *a* is the fuse-hole. The pattern of the shell is a plain globe, (fig. 2,) of the same external diameter as itself, having a core print, *a*, upon it, answering to the fuse-hole, and of the same diameter. Fig. 3, represents the core, of which the diameter is the same as that of the interior of the shell; it has a projection, *a*, to form the fuse-hole. The whole core is formed in a box which opens in two semispherical parts, to allow the core to be extracted. A piece of double-twisted wire is enveloped in the core, projecting at the neck with a loop at the outer end. By this wire the core is to be held down. Fig. 4, is a section of the moulding-box and the moulding, showing the core in its situation, and the applications for holding it there by means of the wire, which passes through the bottom of the moulding, and is locked on the under side. Two gates are also represented, by which the metal is poured.

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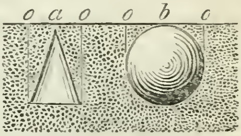
* In the last article, by a slight overlook, these objects are named steeples.

It is evident, then, that when the casting is formed, the fuse-hole is the only exit for the core sand in the interior. The material of the core, ought, therefore, to be easily friable, as it can be broken down only by external blows. Accordingly, it is formed of free sand, so tempered with clay-water, or other binding principle, as to acquire just such a tenacity as will enable it to bear the action of the metal. The fuse-hole core is made of rock sand to enable it to bear the weight of the body of the core, and to withstand the strains to which it may be subjected. The surfaces of the core, and the exterior moulding, are washed with a mixture of blackening and water, to communicate smooth interior and exterior surfaces to the shell. A pricker is sent into the heart of the core through the neck, forming, by this means, a passage for the escape of the air confined throughout its substance.

Our next examples are intended to illustrate, generally, the manner of constructing patterns, in an exigency which frequently occurs, namely, when certain portions of a pattern enveloped in the sand, project horizontally beyond other parts which are above them. Were the pattern, in such circumstances, to be formed in one piece, it obviously could not be withdrawn from the sand without breaking up the moulding at the parts referred to. This idea may be explained by the annexed figures; *a*, *b*, fig. 5, being respectively a cone and a sphere. Were these objects buried in the sand, as shown in the fig., and then drawn out, the base of the cone would describe the space included in the vertical lines, *o*, *o*, and would, also, of course, remove the overlying sand. A similar result would ensue with the sphere. The lower part of the mould of the sphere would be left as it is, while the upper part between the lines, *o*, *o*, would be destroyed. The simple remedy for these cases would be to invert the position of *a*, as shown in fig. 6, and to mould the sphere, *b*, so as to have its largest horizontal diameter at the surface of the sand. While the under half could thus be moulded in the under box, the upper half would be rammed up in the upper box. As in these, so in all other instances, patterns, or parts of patterns, to be capable of being moulded in sand, must, in their general outline, taper from the surface of the sand downward. For this reason, such parts of the surface of a

Fig. 5.



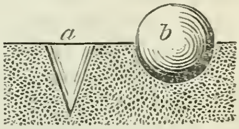


Fig. 6.

pattern as may be intended to be vertical, when it is being moulded, are never made truly so. A slight tapering inclination is given them, that they may leave the sand the more readily.

A variety of other peculiar circumstances, however, frequently occurs, which require special methods of management. For example, a common sheave requires a particular, and an elegant process, to execute the moulding of it. Fig. 7, is a diametrical section of one. The circumference, it will be observed, is grooved out semi-circularly at *a, a,* and a hole, *o,* is made through the centre. The object is now to mould the pattern in such a manner as that the portion of sand forming the groove, *a, a,* may be left in its place when the pattern is drawn out. The pattern, fig. 8, must be formed in two halves, separated by a plane, *a, a,* passing through the centre of the groove. These halves are prevented from shifting by pins, *n, n,* or this may also be effected by a button on the centre of the one, fitting a recess in the other, as in the figure. There are also prints at *o, o,* for supporting the core.

Fig. 7.

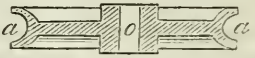


Fig. 8.

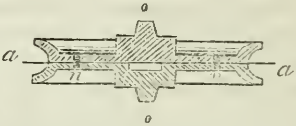
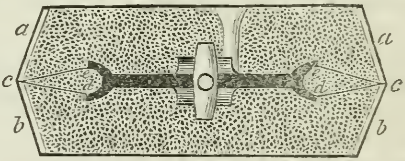


Fig. 9, represents, in section, the moulding of the pulley ; *a, a,* and *b, b,* are the boxes. The pattern is first bedded in the lower box, and a parting, *c, d,* formed from the under rim to the edge of the box. The ring of sand, *c, d, e,* is, in the next place, rammed about the pattern, filling the groove, and its upper parting surface, *c, e,* is brought from the upper rim. Again, the upper box is placed on the other, and also filled.

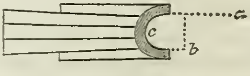
Fig. 9.



The ramming being now completed, and the gate-pin set, the box, *a, a,* is lifted off, carrying with it the impression of the upper side of the pattern. The upper half of the pattern being free, is lifted away, and the box, *a, a,* replaced. The whole is now inverted, and the box, *b, b,* is lifted off, thus permitting the remaining part of the pattern to be removed, which being done, and the moulding blackened and smoothed, and the core, *o,* set in, the box is replaced, and the two are finally reinverted. It will be observed, that the annular core, *c, d, e,* is never lifted from its situation during the process, and when the two boxes are linked together, it is wedged in on every side, and thus all possibility of shifting is removed.

Where there may not be facilities for turning the patterns of pulleys of large diameter, the grooves are cored out in the moulding. For this purpose, a core-print, running round the pattern, is provided in the making, as sketched in fig. 10, which is a section of the rim of a wheel supposed to be made with arms. The print is indicated by the dotted lines, and a core of the sectional

Fig. 10.



form, *a*, *b*, *c*, is constructed in a core-box for the purpose. As there are only two boxes for the moulding, the pattern is mostly imbedded in the under one, the parting being formed on a level with the core print at *a*. It is not necessary that the core be all one piece; it may, for convenience, be formed in several segments.

We shall now select a fluted stove-pipe, as an example of another variety of adaptation. Fig. 11, is a transverse sectional view of the pipe, which may be supposed to be about five inches diameter, six feet long, and three-sixteenths of an inch thick. It will be observed, that the core, or interior of the pipe, follows in form the exterior surface, the object being to make the pipe as light as possible, otherwise a round core might have served the purpose.

Fig. 11.

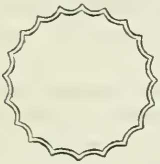


Fig. 12.

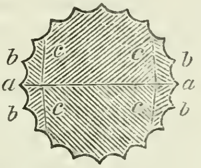
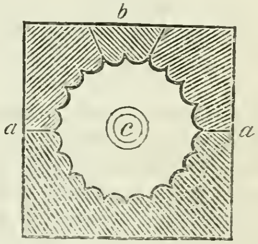


Fig. 13.

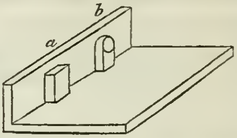


To determine, then, the method of casting this pipe:—It is to be noted, in the first place, as a general rule, that all cylindrical bodies of any considerable length, are moulded in two boxes, one half in each. Agreeably to this, the patterns are usually divided longitudinally in two halves. Referring to fig. 12, which is a cross section of the stove-pipe pattern, the line, *a*, *a*, represents the main division, which would suffice for a pattern having a plain exterior. For this column, however, deep as the flutes are, subdivisions are necessary to render the moulding of it practicable. For it is easily seen that the angles, *b*, *b*, *b*, *b*, immediately adjoining the parting, *a*, *a*, overhang the bottom of the hollows between *a* and *b*, and, therefore, if the patterns were drawn vertically out of the sand, they must break away the intervening portions of sand that occupy these hollows. Such parts of the pattern require to be removed laterally, and for this purpose, each half is made in three divisions, as represented at *c*, *c*, *c*, *c*, dovetailed to one another—allowing the smaller pieces to slide off the larger. Fig. 13, represents the core-box for the pipe. It is, like the pattern, parted in two at *a*, *a*. In the top of the upper half a loose piece, *b*, the length of the box, is provided, which being removed, the sand for the core may be introduced by the opening; *c*, is the core-bar, which runs the whole length for the purpose of stiffening the core.

The pattern having been moulded in the usual manner, one half in each box, so that the plane, *a*, *a*, fig. 12, coincides with the parting of the sand, the middle piece of each half is first drawn out, when the smaller pieces may next be removed laterally, to make way for the core.

On this principle of construction, in similar circumstances, patterns are generally made. Fitting strips, for example, when applied to the vertical face of a pattern, below the surface of the moulding, are attached to it by sliding dovetails. Core prints are very often placed in such circumstances. In fig. 14, which is the pattern of a flanched plate, *a* and *b*, are two core prints, which, instead of being dovetailed to the pattern, are carried quite down to the plate, which is moulded in an inverted position; these continuations clear the way for the prints themselves, which would otherwise break the moulding. After the cores are introduced, these temporary vacancies are filled up with the aid of smooth strips of wood, and the figure of the moulding restored. In general, core prints, on vertical faces of patterns, are carried up to the parting surface with the view of making their own passage, which is afterwards closed over the core.

Fig. 14.



Take, for our next example, a paneled octagon column, or post. It presents a more complicated structure than the stove-pipe, and to render it workable in the sand, the panels are, each by itself, made separable from the body of the pattern, being attached to it by screw-nails, which are driven off the inside. The pattern is divided into two principal halves. When it is moulded, the panels, of which there are four to each half, are fixed on. When the parts of the box are separated, exposing each a half interior of the pattern, the screws are returned and withdrawn, thus leaving the frame of the pattern at liberty from the panels. It is next lifted out, and these being disengaged from the sand by tapping, are likewise taken out in order. In this way a complete external moulding of the column is formed. The core, constructed upon a stout bar, is next inserted, and the box closed upon it.

Fig. 15.

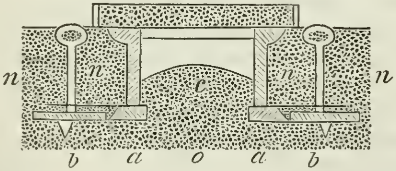
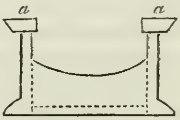


Fig. 16.



Of the use of plates in moulding, an example has already been given in our last paper in the account of the moulding of an engine sole-plate. A different application will now be described in relation to the moulding of a lathe-bed. Fig. 15, is an end view of the bed; *a*, *a*, are the upper sliding surfaces, overhanging the sides; these are connected and stiffened at several parts by deep flanches joining them. The surfaces, *a*, *a*, as they are the most important parts of the bed, are, according to the general rule, moulded undermost, the object being to secure a sound structure, at these parts, free from blown holes and impurities, which collect, more or less, towards the upper side of every casting. Fig. 16, is a section of the pattern and moulding.

The parts, *a, a,* are simply attached by loose pins to the rest of the pattern. The first step is to bed the pattern in an inverted position, thoroughly on the floor, which is levelled and smoothed all about it. Plates, *b, b,* extending the whole length of the pattern, are sent along both sides of it, an inch or so apart, to support the sand exterior to the pattern. A series of small rods, either of wood or iron, is placed on each plate. These rods overhang it on the side next the pattern, from which, however, they must be at some distance. In this way, the rods form a projecting platform, by which the sand that would overhang the plate is sustained. If of wood, the rods are dipped in clay-water, that they may adhere to the sand. The moulding is now made up with sand, flush with the pattern within and without. The parting surface is formed, and covered in by the upper box in the usual manner, which, being lifted off, and the pattern having been loosened, it is drawn out, leaving the loose pieces, *a, a,* imbedded in the three masses of sand, *n, n, o.* The masses, *n, n,* resting on the plates, are raised and moved aside by handles which are cast upon the plates, and project upwards. The pieces, *a, a,* being thus relieved, are edged out from below the sand, *o,* and removed. *n, n,* are replaced as before, guided by conical projections from the plates, and the moulding is covered in by the upper box.

Plates are also employed in the moulds of bevel-wheel patterns for lifting the bodies of sand sunk between the arms. Frequently, too, in miscellaneous cases, where considerable depths of sand occur in the upper part of the mould, slips of wood are planted vertically in the masses, reaching upwards between the ribs of the upper box, their object being to bind the whole body of sand the more firmly together.

(To be continued.)

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FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

## *Dynamometer for the Measuring of Steam, or Water, Power.*

In your Journal for May, I find an article from the Edinburgh New Philosophical Journal, dated from Manchester, "On the method of registering the force actually transmitted through a Driving Belt; by Edward Lang, Esq., Professor of Civil Engineering, College, Manchester."

The method proposed is founded upon the extension, or stretch, of the belt, by the force communicated through it. That is, that the working side of the belt will be more extended than the slack side, and, consequently, the pulley on the machine will not revolve through so many inches, in a given time, as the drum that communicates the motion; or, in other words, suppose the working side of a belt may be extended one, two, or three, inches in an hundred, more than the slack side, it will, of course, lap round the driving drum, in that extended state; while the opposite side is received upon the driven pulley in the slack state, and will communicate so much less motion, and as the difference between the motion communicated to the pulley, and that of the drum, will bear a certain proportion to the strain on the belt in each individual instance, the author says:—"We have only to contrive some method of registering this difference, in order to have a record of the total force transmitted by the belt." He then proceeds to a practical application of the principle, and proposes a plan for indicating the difference between the motion of the drums and the pulley, and also experiments with a particular belt, to ascertain what *force* a certain difference in these motions would indicate. He then says, "when the multiplier for one belt has been ascertained, that for any other belt may be approximately computed, if it be of the same material, by having regard to the relative weight of a foot of each," &c.

The reason of my calling your attention to this article, is, that the proposal of so imperfect and complicated a plan, shows the want of a good Dynamometer for this purpose, and that neither the writer of the article, a professor of civil engineering in the college of Manchester, nor the editor of the Philosophical Journal at Edinburgh, (though both might be supposed to be well informed on such matters,) were acquainted with a very simple and accurate instrument constructed for the purpose in this country, to which I am about to call your attention, as described in an article in the Monthly Chronicle, published in Boston, November, 1840.

"At the Mechanics' Fair in Boston, in September, 1839, an ingenious and valuable machine was exhibited, the purpose of which is to obtain an accurate measurement of the degree of power, exerted at any time, in the movement of machinery, while in regular operation. It is applicable alike to steam, or water, power, and is susceptible of being made of either large dimensions, for the measurement of the power of large water-wheels, or engines, or of smaller dimensions, applicable to the more exact measurement of the power exerted in the movement of light machinery. It is the invention of Samuel Batchelder, Esq., of Saco, the Agent of the York Cotton Factory. It is on a principle, which, we believe, is entirely novel, yet simple, and manifestly applicable to the accurate attainment of its object. In applying it to use, in any particular case, it is only necessary to place it in the line of communication, between the engine and machinery to be moved, by means of drum-belts, or gearing. When it is so placed, forming a line of connexion between the moving power, and the machinery to be moved, the degree of force exerted in overcoming the resistance to the motion of the machinery, at any given time, is accurately measured, by means of a steel-yard bar and weight. The position of the weight on the graduated bar, required for keeping this bar balanced in a horizontal position, indicates the measure, in pounds, of the power exerted at the time. There is connected with the machine an index, to show the number of revolutions of the drum connected with the water-wheel, or steam-engine, in a given time, by which, together with the weight, or resistance, to the motion, it will be readily shown how many pounds would be raised a foot high per minute, or in any other space of time, by the degree of power then exerted. The form of the machine is illustrated by the following drawings

Fig. 1.

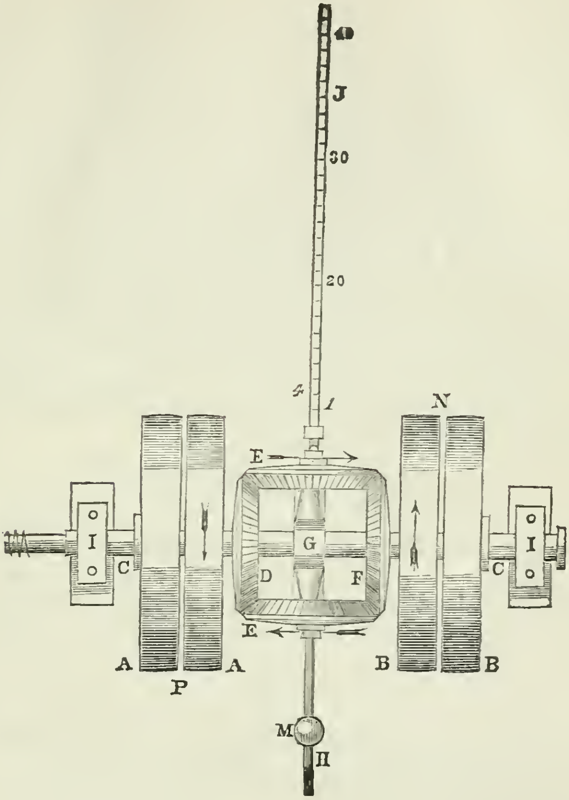
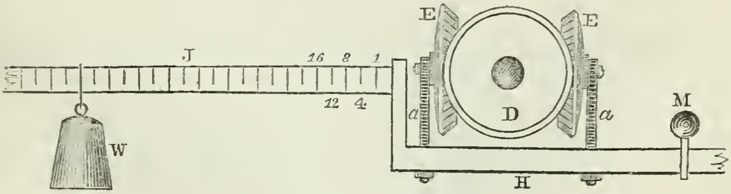


Fig. 2.



The cuts, figures 1 and 2, give a view of the dynamometer, in which AA, and BB, denote two pair of belt pullies, each pair consisting of a fast and loose pulley. The operation of the machine is to receive the motion, or power, from the drum, or prime mover, by a belt upon the pulley, A, and to transmit it to the machine, which is the subject of experiment, by a belt on the pulley, B. The fast pulley, A, and the bevil wheel D are fast upon the shaft, CC, which revolves in the bearings, I I. The bevil wheel F, is connected with the pulley, B, by a tube, or hub, through which passes the shaft, CC, upon which this pulley and wheel are supported, the shaft revolving freely in the tube, or hub. In order to give motion to the pulley, B, a connexion must be formed between the bevil wheels, D and F; for this purpose they are geared together by the bevil wheels, EE, which run upon a cross shaft, through which the main shaft passes freely, at G. Now, it is evident, that if this cross shaft is not held in its place by some force, the motion of the bevil wheel, D, will only cause the shaft to move round and round upon the shaft, C, and the wheels, EE, rolling upon the wheel, F, without communicating to it, or to the pulley, B, any motion; but if the wheels, EE, and the shaft, G, are held in place, the motion of the pulley, A, will be communicated to the pulley, B, through the bevil wheels, and the force there applied to retain the shaft, G, and the wheels, EE, in place, will indicate the power transmitted through the dynamometer. This power is ascertained by means of a graduated beam, like that on a common balance, or steelyard, as represented by H J, attached to the shaft of the wheels, EE, as represented in fig. 2, by the straps, *a*, *a*.

The weight, M, fastened by a set screw, affords the means of balancing the lever horizontally, when the machine is at rest; and a weight, W, like that of the common balance, moved upon the graduated arm of the lever, will indicate the strain upon the belt. The number of pounds thus indicated, multiplied by the number of feet through which the belt moves per minute, will give the number of pounds raised one foot high per minute, according to the usual manner of estimating the power of steam engines, or other prime movers, allowing, as usual, 33,000 pounds raised one foot high per minute, to the horse power. A worm, on the end of the shaft, CC, is made to move an index, which shows the number of feet through which the belt, or the surface of the pulley, moves in a given time.

In graduating the arm of the balance, J, the division, marked 10, is at the same distance from the centre of the shaft, C, with the surface of the pullies, or equal to the radius of the pulley. The same additional distance is marked 20, and again the same 30. Now, if we suppose a power of 10 pounds applied to the pulley at P, it will balance the same weight on the opposite pulley at N; but it ought to be kept in mind that it will require a weight of 20 pounds at 10, to balance and keep in place the arm of the lever; for, as the pivot of the wheel, E, acts as a fulcrum, it must not only sustain the power exerted by the wheel, D, but the power communicated to the wheel, F, so that a counterbalance of 20 pounds must be used, to correspond with the numbers, 10, 20, 30, upon the graduated arm of the lever.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

## *On the Strength of Cylindrical Steam Boilers.*

Mr. Bakewell, of Cincinnati, replies to our article published in the July number of the Journal, (page 54) on the Strength of Cylindrical Boilers. Mr. B. misapprehends us; we do not, in our solution, assume any "parallelism in the action of the steam," as he supposes; but we admit that it acts, like other elastic fluids, perpendicularly to the inclosing surfaces—in this case the periphery of the cylinder. We have no objection to the new hypothesis which Mr. B. introduces, of a solid body below the line A, B, to which the semi-cylinder, A, B, D, is supposed to be attached, although we deem it unnecessary. The supposition, as he correctly states, does not alter the conditions of the problem. But then he errs greatly when he jumps to the conclusion, that "the operative force to produce rupture at B," would, by the received theory, be but one-half its value at D. Our equation—which is in accordance with the received theory—leads to no such incongruous result.

The general expression of the moment of the force, with reference to A, is,

$$\int \mathrm{F}x\frac{dx}{ds}ds+\int \mathrm{F}y\,\frac{dy}{ds}\,ds.$$

Now, if B be the point selected for the rupture, we have $x=\text{rad.}=\frac{\delta}{2}$, and must, accordingly, integrate from $x=o$, to $x=\frac{\delta}{2}$. By the operation we obtain,

$$\mathrm{F}\frac{\delta^2}{4}$$

for the moment of the force. The resistance of the metal is $\mathrm{P}t$; and the arm of the lever, by which it acts, is $\frac{\delta}{2}$, consequently, the moment of the resistance is here,

$$\mathrm{P}t\frac{\delta}{2};$$

which must be equal to the moment of the force; whence results,

$$\mathrm{F}=\frac{2\,\mathrm{P}t}{\delta},$$

as given by Mr. Latrobe. If Mr. Bakewell had read our former solution carefully, it would have spared him much trouble. E.

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## *On a Self-acting Circular Dividing Engine; read before the Roy. Astron. Soc. Lond. June 9, 1843.* By W. Simms, Esq.

The original graduation of a circle, notwithstanding the great improvements in the method invented by Mr. Troughton, is still attended with very great difficulties, requiring not only the greatest care, on the part of the operator, but tending to injure his health by the labors required in it, and thus not admitting of frequent repetition. The necessary cost of an instrument produced by such an amount of severe labor, is also another very serious objection. The author had long been of opinion, that to copy the divisions of a circle which had been graduated with extraordinary care, upon work of smaller dimensions, would, in general, be more satisfactory than original graduation. The latter process consists of several successive steps, in either, or all, of which a certain amount of error may escape detection, which, in general, may go far to balance one another, although there will be parts in almost every work where errors appear arising from an accumulation of those minute quantities.

The author had long since determined, as soon as he could obtain sufficient leisure, to construct an engine sufficiently large for the graduation of all circles, excepting those of the largest class, and the object of this paper is to lay before the Society, a brief notice of the successful termination of the work.

The engine, in general arrangement and construction, is similar to that made by Mr. Edward Troughton, in the author's possession, though there are several additions and peculiarities which are pointed out by him. The circle, or engine-plate, is of gun-metal, 46 inches in diameter, and was cast in one entire piece by Messrs. Maudslay and Field, teeth being ratched upon its edge. The centre of the engine-plate is so arranged that it can be entered by the axis of the instrument to be divided, and the work, by this means, brought down to bear upon the surface of the engine-plate, which arrangement prevents the necessity of separating the part intended to receive the divisions from its axis, &c.—a process both troublesome and dangerous.

Upon the surface, and not far from the edge of the engine-plate, are two sets of divisions to spaces of five minutes, one set being in silver, and the other strongly cut upon the gun-metal face. There are also as many teeth upon the edge, as there are divisions upon the face of the engine-plate, namely, 4320, and, consequently, one revolution of the endless screw moves through a space of five minutes. The silver ring was divided according to Troughton's method, with some slight variations. In this operation it seemed to the author the safer course to divide the circle completely, and then to use a single cutter for ratching the edge; and he believes that the teeth upon the edge have been cut as truly as the original divisions themselves.

Another very important arrangement is, that the engine is self-acting, and requires no personal exertion, or superintendence, nothing being necessary but the winding up of the machine, or rather the raising of a weight, which, by its descent, communicates motion to the dividing engine. The machinery is so arranged, that it can be used, or dispensed with, at pleasure, there being some cases in which a superintending hand is desirable.

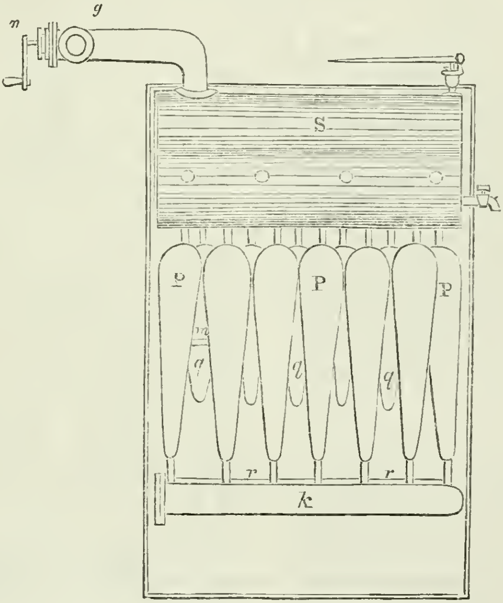
The author then proceeds with a description of the machinery, as represented in the drawings accompanying his paper, and draws particular attention to the contrivance by which the engine can discharge itself from action when it has completed its work.

He concludes by observing, that as the machinery is simple, by no means expensive, can be made by an ordinary workman, is adapted to all the engines now in existence, which are moved by an endless screw, as it lessens the labor of the artist, and increases the accuracy of the graduated instrument, he trusts his communication will prove acceptable to all who are interested about such matters.

Lond. Edin. & Dub. Phil. Journn.

## *On the Steam Power of Mr. Henson's Flying Machine.*

Fig. 1.



The difficulty of mechanical flying consists less in devising an apparatus capable of floating in, and being moved through the air in any given direction, than in freighting it with mechanical power sufficient to enable it to maintain its place through long distances against the constantly adverse influence of gravitation, and the frequently concurring opposition of the wind and weather. The means by which Mr. Henson hopes to overcome this difficulty, that is to say, the boiler by which he proposes to generate steam enough for any given length of flight, deserve, therefore, a little more consideration than they have as yet received at our hands. We, therefore, lay before our readers the accompanying engravings of the boiler, with the explanations furnished by Mr. Henson himself in his specification.—[Ed. *London Mech. Mag.*]

Fig. 1, represents a side elevation, and fig. 3, a front elevation of the boiler; figs. 2 and 4 are top and bottom sectional views. S, is the body, or principal part, of the boiler, consisting of three cylinders, the steam from which passes off through the pipe, *g*, which is provided with a valve. The smaller cylindrical vessels, *t*, *t*, are joined by the pipes, *u*, (four of which are indicated by dotted circles in fig. 1.) The larger conical vessels, P, P, P, connect the pipe, *k*, *k*, and the principal cylinders of the boiler, in the manner shown in the figures. The smaller vessels, *q*, *q*, are connected to the principal cylinders, as also to the vessels, P, P, as shown at *m*, figs. 1 and 3. The furnace is divided into two compartments by the vessels, P, P, P, as seen in fig. 2. *r*, *r*, are the furnace-bars, resting on the pipe, *k*, *k*, so that the vessels, P and *q*, are subjected to the full power of the fire; *f*, *f*, is the place of exit for the smoke.

Fig. 2.

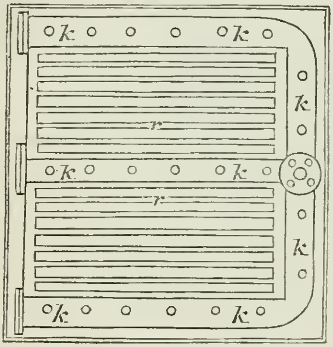


Fig. 3.

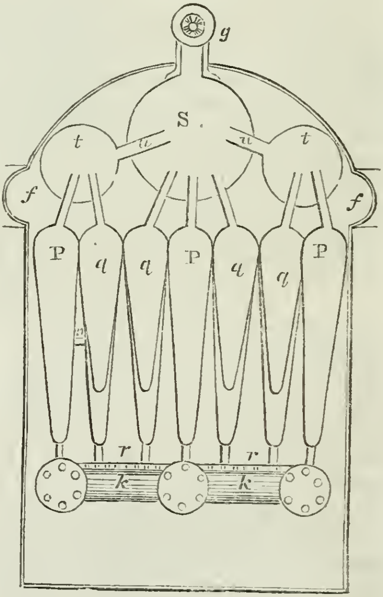
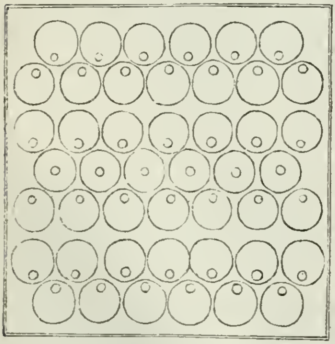


Fig. 4.



The vessels, S, *t*, P, and *q*, Mr. Henson proposes making of copper, and the joinings of brass, on account of the greater strength of copper when compared with iron, weight for weight, and also on account of its greater heat-conducting power.

The two induction and eduction valves of the engine, which are simply cocks varying little from the ordinary form, are to be worked by four eccentric wheels.

## *On the Electricity evolved by the Friction of Water and Steam against other bodies.* By MICHAEL FARADAY, ESQ.

The object of the experiments related in this paper, is to trace the source of the electricity which accompanies the issue of steam of high pressure, from the vessels in which it is contained. By means of a suitable apparatus, which the author describes and delineates, he found that electricity is never excited by the passage of pure steam, and is manifested only when water is at the same time present; and hence he concludes, that it is altogether the effect of the friction of globules of water against the sides of the opening, or against the substances opposed to its passage, as the water is rapidly moved onwards by the current of steam. Accordingly, it was found to be increased in quantity, by increasing the pressure, and impelling force of the steam. The immediate effect of this friction, was, in all cases, to render the steam, or water, positive, and the solids, of whatever nature they might be, negative. In certain circumstances, however, as when a wire is placed in the current of steam at some distance from the orifice whence it has issued, the solid exhibits the positive electricity already acquired by the steam, and of which it is then merely the recipient and the conductor. In like manner, the results may be greatly modified by the shape, the nature, and the temperature of the passages through which the steam is forced. Heat, by preventing the condensation of the steam into water, likewise prevents the evolution of electricity, which again speedily appears by cooling the passages, so as to restore the water which is necessary for the production of that effect. The phenomenon of the evolution of electricity in these circumstances, is dependent also on the quality of the fluid in motion, more especially in relation to its conducting power. Water will not excite electricity unless it be pure; the addition to it of any soluble salt or acid, even in minute quantity, is sufficient to destroy this property. The addition of oil of turpentine, on the other hand, occasions the development of electricity of an opposite kind to that which is excited by water; and this the author explains by the particles, or minute globules, of the water having each received a coating of oil, in the form of a thin film, so that the friction takes place only between that external film and the solids, along the surface of which the globules are carried. A similar, but a more permanent, effect is produced by the presence of olive oil, which is not, like oil of turpentine, subject to rapid dissipation. Similar results were obtained when a stream of compressed air was substituted for steam in these experiments. When moisture was present, the solid exhibited negative, and the stream of air positive electricity; but when the air was perfectly dry, no electricity of any kind was apparent. The author concludes with an account of some experiments in which dry powders of various kinds were placed in the current of air; the results differed according to the nature of the substances employed, and other circumstances.

Lond. Athenæum.

## *On the Action of Water on Lead; read before the Royal Society of Edinburgh.* By Dr. Christison.

The author, after briefly stating the results of his experimental inquiries, published on this subject in 1829, proceeded to describe two instances which had recently come under his notice, illustrative of the solvent action of certain terrestrial waters on lead, and of the danger of using this metal for conducting water in pipes, unless with a due regard to the circumstances which promote, or prevent, its corroding property. In one instance, the water of a spring, conveyed in a lead-pipe from a distance of three quarters of a mile, was found to act so powerfully on the lead, that in a short time the cistern in which the water was collected became covered with loose carbonate of lead, and the metal could easily be detected in the state of oxide dissolved in the water. In this case, the action was found to depend on the spring being of extraordinary purity, its total saline ingredients being only a 22,000th part. In the other instance, water conveyed half a mile in a lead pipe, was impregnated exactly in the same way, and with the very same phenomena—but with the additional circumstance, that, in consequence of the impregnation not having been detected in time, as in the previous case, the disease, *Colica pictonum*, broke out in the house supplied with the water. In this case, the water was by no means pure, as it was found to contain no less than a 4,500th part of saline matter. But there was scarcely any other salt present except muriates, which the author had ascertained in his former researches not to prevent the action of water on lead, unless present in much larger quantity.

He next proceeded to explain in what manner the action of the water was put an end to in both these cases. In similar instances, the only remedy formerly thought of was substitution of iron-pipes. In the former of the two cases which fell under his notice, the water was left at rest in the pipe for four months, till a firm crust of mixed carbonate and sulphate of lead had crystalized on the lead; after which no farther action took place. In the latter instance, the same end was attained by keeping the pipe full of a solution of phosphate of soda, consisting of 27,000th of the salt.

The author appended an analysis of the compound formed by the action of distilled water on lead. Guyton-Morveau and others considered it a hydrated oxide; the author himself, in 1829, thought it a neutral carbonate; and, in 1834, Captain Yorke first considered it a hydrated oxide, and eventually concluded from his analyses, that it is an irregular mixture of hydrated oxide and carbonate of lead. The author finds that the product is a hydrated oxide, when the action goes on without the access of carbonic acid; but that, when the action proceeds in the usual way, under exposure to the atmosphere, the product is a crystalline body, of which the primitive form seems to be the regular octahedron, and which is composed of two equivalents of neutral carbonate, united with one equivalent of hydrated oxide $(2\,\mathrm{PbO}\,\mathrm{CO}^2 + \mathrm{PbG}\ \mathrm{Aq.})$

He then stated the following to be the general conclusions to be drawn in a practical point of view, from his present and previous inquiries as to the use of lead for conveying water :

1. Lead-pipes ought not to be used for the purpose of conveying water, at least where the distance is considerable, without a careful chemical examination of the water to be transmitted.

2. The risk of a dangerous impregnation with lead is greatest in the instance of the purest waters.

3. Water, which tarnishes polished lead, when left at rest upon it in a glass vessel for a few hours, cannot be safely transmitted through lead-pipes without certain precautions.

4. Water, which contains less than about an 8000th of salts in solution, cannot be safely conducted in lead-pipes, without certain precautions.

5. Even this proportion will prove insufficient to prevent corrosion, unless a considerable part of the saline matter consist of carbonates and sulphates, especially the former.

6. So large a proportion as a 4000th, probably even a considerably larger proportion, will be insufficient, if the salts in solution be in a great measure muriates.

7. In all cases, even though the composition of the water seems to bring it within the conditions of safety, now stated, an attentive examination should be made of the water, after it has been running for a few days through the pipes. For it is not improbable that other circumstances, besides those hitherto ascertained, may modify the preventive influence of the neutral salts.

8. When the water is judged to be of a kind which is likely to attack lead-pipes, or when it actually flows through them impregnated with lead, a remedy may be found either in leaving the pipes full of the water, and at rest for three or four months, or by substituting for the water a weak solution of phosphate of soda, in the proportion of about a 25,000th part.

Edin. New Phil. Journ.

## English Patents.

*Specification of a Patent granted to* William Cotton, Esq., of Leytonstone, *for an improved Weighing Machine. Patent dated June* 13, 1842; *Specification enrolled August* 10, 1842.

Mr. Cotton, who is Governor of the Bank of England, has invented this machine for the purpose of weighing sovereigns, and separating the light ones from those of standard weight. It is so delicate, that it detects, with precision, a variation of a twelve thousand two hundred and fiftieth part of the weight of a sovereign. The coins are placed in a tube, or hopper, from whence they are carried on to a small platform, which is suspended over a delicately poised beam, to the other end of which is appended the standard mint weight. On setting the machine at work, a sovereign is placed on the platform, and if it is full weight, a small tongue advances, and strikes it off into a till appointed to receive it; but, if it is light, the platform sinks, and brings it within the reach of another tongue, at a lower level, which advances at right angles to the former tongue, and pushes the coin into another till. Other coins succeed in rapid rotation, so that the machine can weigh, and sort 10,000 sovereigns in six hours, while an experienced teller, can, at the utmost, only weigh between 3,000 or 4,000 coins, by hand-scales, in the same time, and even then, the optic nerve, by incessant straining, becomes fatigued, and errors occur.

Lond. Mech. Mag.

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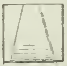
*Specification of a Patent granted to* Samuel Dotchin, of Hoxton, *for improvements in paving, or covering and constructing roads, ways, and other surfaces. Sealed* 8*th October*, 1842.

These improvements consist in paving roads, &c., with blocks of wood, or other suitable material, of the peculiar form represented in fig. 1, which is a side view, and fig. 2, a plan of the block; the latter fig. being encompassed by a circle, to shew that it may be cut out of a circular block, or piece of timber. The improved block consists of six sides, and an upper and lower surface; the sides are all equal, but, instead of being formed perpendicular to the upper and lower surfaces, they incline alternately in opposite directions. The advantages to be derived from this form, are, that each block will be supported by three of the adjoining blocks, and will also support three, as shewn at fig. 3, which is a plan of part of a pavement; the spaces between the upper parts of the blocks are filled with asphalte, sand, &c.

Fig. 1.



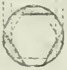
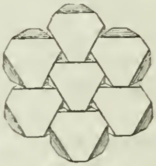


Fig. 2.

Fig. 3.



The patentee does not claim the use of blocks of wood, or other material, with six sides, generally, but only when the sides are caused to incline in opposite directions, as shewn in the drawing, in order that each block may support, and be supported, by the surrounding blocks. He claims, also, combining a series of blocks, of the figure above described, for paving, or covering, and making roads, ways, or other surfaces.—[Enrolled in the Enrolment Office, April, 1843.]

Ibid.

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*Abstract of a Patent granted to* Charles Keene, of New Bond street, *for improvements in the manufacture of hose, socks, drawers, gloves, mitts, caps, comforters, and cuffs.* Patent dated December 15, 1842; Specification enrolled June 15, 1843.

Mr. Keene premises, that he has found that when fabrics into which threads of Indian rubber have been introduced, are cut up in lines parallel to these threads, the cloth is not apt to fray, or fringe, out. Applying this fact, he forms elastic bands for the wrists of gloves, by introducing threads of Indian rubber as weft, or warp. In either case he forms a band of sufficient width for the required wrist; between the threads of Indian rubber, he introduces one or two picks of wool, or cotton, &c., according to the fabric, but preferring wool. Immediately in contact with this band, there is woven a sufficiency of stuff, from which may be cut the glove, leaving the band at the top to become the wrist, so that the web may consist of as many breadths, or lengths, as may be convenient, taking care only, to have a band, into which has been woven the India rubber, to become the elastic wrist. The caoutchouc may be rendered elastic in the usual manner, either before it is woven, or afterward.

Another part of the invention has reference to the manner of cutting out, or forming, what he calls *overalls* for gloves, stockings, mitts, caps, drawers, &c., which are used to keep the gloves, &c., underneath, close to the body for warmth. They are to be cut from a web into which threads of India rubber have been introduced, either as warp, or weft, or from a fabric formed similar to that made by the warp lace machines, either diagonally, or longitudinally. The overalls, &c. &c., are to be cut in such a manner, that the threads of Indian rubber shall take a diagonal direction over the hand, when they will be found readily to yield to the form of the hand, &c.

The claims are: 1. To the application of elastic bands, made in warp machines, as above described.

2. The making of the fabric in manner above described, so that when the gloves, &c., are cut out, there shall be an elastic band for the wrist.

3. The mode above described, of making overall gloves, mitts, &c., so that the threads of Indian rubber shall always lie in a diagonal direction across the hand, &c., whether the fabric be made by the common warp, or by warp lace machines. Ibid.

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## *Abstract of a Patent granted to* William Henry Fox Talbot, Esq., of Laycock Abbey, *for improvements in coating, or covering, metals with other metals.* Patent dated November 25, 1842. Specification enrolled May 25, 1843.

The specification of Mr. Talbot's present patent discloses no new principle in the art of metallic precipitation; but it supplies some very useful improvements in its manipulative details.

1. To prepare metal articles for gilding, Mr. Talbot dips them in a weak solution of silver in hyposulphite of soda.

2. To prepare an article for either gilding, or silvering, he first cleans it well, then connects it to one of the wires of a voltaic battery, next plunges both poles into a vessel filled with some acid solution, which, decomposing the water, the hydrogen is given off by the article intended to be gilt, or silvered. After a little time the article is detached from the battery, and thrown into a solution of gold or silver, where it speedily acquires the required coating.

3. To gild metallic articles, he makes use of a mixed solution of gold, and any one of the baser metals, with the exception of mercury, which would separate the gold.

4. He also uses for gilding, a solution of chloride of gold, mixed with a solution of boracic acid, the latter having the effect of greatly improving the color.

5. To remove the dark tint which metallic articles sometimes acquire when dipped in a solution of gold, they are immersed in a very weak solution of nitrate of mercury. Any mercury which may adhere, is afterwards removed by an acid, assisted by voltaic action.

And, 6. When, in silvering an article, the solution of silver ceases to impart any addition to the coating, (in consequence of the coating and the solution becoming of identical properties,) Mr. Talbot dips it into a different solution of silver, or into a solution of some other metal, after which he replaces it in the first solution, when it is found to act with the same energy as at first. The same method of alternate dipping is also applicable to solutions of gold. Ibid.

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METEOROLOGICAL OBSERVATIONS FOR FEBRUARY, 1843.

| Moon. | Days. | Therm. | | Baromtr. | | Wind. | | Water Fallen in rain | State of the Weather, an Remarks. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Sun Rise. | 2 P. M. | Sun Rise. | 2 P. M. | Direction. | Force. | | | |
| | 1 | 33° | 26° | 29.36 | 29.36 | NW. | Moderate | | Cloudy. | Cloudy. |
| | 2 | 18 | 26 | 29.70 | 29.86 | W. | Blustering | | Clear. | Clear. |
| | 3 | 20 | 33 | 30.10 | 30.10 | S. | Moderate | | Clear. | Clear. |
| | 4 | 24 | 38 | 30.10 | 30.10 | S. | do | | Hazy. | Hazy. |
| | 5 | 34 | 32 | 29.70 | 29.36 | NE. | do | | Cloudy. | Cloudy. |
| | 6 | 21 | 23 | 29.33 | 29.50 | W. | Blustering | | Cloudy. | Par. cloudy. |
| ☾ | 7 | 12 | 22 | 29.70 | 29.75 | W. | do | | Par. Cloudy. | Clear. |
| | 8 | 11 | 20 | 30.10 | 30.15 | W. | Moderate | | Clear. | Cloudy. |
| | 9 | 12 | 26 | 30.27 | 30.27 | W. | do | | Clear. | Lightly cloudy. |
| | 10 | 19 | 32 | 30.35 | 30.30 | E. | do | .66 | Cloudy. | Lightly rain. |
| | 11 | 41 | 40 | 29.60 | 29.66 | W. | Blustering | | Cloudy. | Clear. |
| | 12 | 33 | 38 | 29.83 | 29.83 | W. | do | | Par. Cloudy. | Clear. |
| | 13 | 24 | 24 | 30.05 | 30.05 | NE. | Moderate | | Flying clouds. | Cloudy. |
| ☺ | 14 | 23 | 23 | 29.90 | 29.83 | NE. | Blustering | | Cloudy. | Cloudy. |
| | 15 | 29 | 24 | 29.45 | 29.45 | W. | do | .65 | Sleet, | Cloudy. |
| | 16 | 12 | 29 | 29.90 | 29.95 | W. | Moderate | | Clear. | Cloudy. |
| | 17 | 13 | 25 | 30.10 | 30.00 | W. | do | | Clear. | Cloudy. |
| | 18 | 11 | 25 | 30.24 | 30.00 | SE. | do | | Cloudy. | Hazy. |
| | 19 | 19 | 33 | 30.05 | 29.90 | NE. | do | | Cloudy. | Clear. |
| | 20 | 33 | 37 | 29.60 | 29.90 | W. | do | | Par. Cloudy. | Clear. |
| ☽ | 21 | 22 | 30 | 29.50 | 29.50 | NW. | Brisk | | Cloudy. | Par. cloudy. |
| | 22 | 30 | 35 | 29.55 | 29.37 | SE. | Moderate | .16 | Cloudy. | Snow. |
| | 23 | 14 | 28 | 29.80 | 29.80 | W. | Brisk | | Clear. | Clear. |
| | 24 | 24 | 36 | 29.80 | 29.75 | E SE. | Calm | | Cloudy. | Lightly cloudy. |
| | 25 | 22 | 38 | 29.70 | 29.70 | W. | do | | Clear. | Lightly cloudy. |
| | 26 | 30 | 47 | 29.80 | 29.50 | W. | do | | Clear. | Lightly cloudy. |
| | 27 | 31 | 43 | 29.50 | 29.50 | W. | do | | Clear. | Lightly cloudy. |
| ⊗ | 28 | 28 | 39 | 30.00 | 30.00 | E. | do | .07 | Clear. | Lt. cloud. snow. |
| | | 22.96 | 31.14 | 29.82 | 29.80 | | | 1.48 | | |

| Thermometer. | | Barometer. | |
|---|---|---|---|
| Maximum 47 on 26th.<br>Minimum 11 on 8th & 18th. | Mean, 27.05 | Max. 30.35 on 10th.<br>Min. 29.33 on 6th. | Mean 29.8 |

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## Civil Engineering.

*Experiments on Water-Wheels, having a vertical axis, called Turbines.* By Arthur Morin, Captain of Artillery, Professor of Machinery in the School of Artillery, &c. &c. *Published at Metz, and Paris,* 1838.

(Translated from the French, by Ellwood Morris, Civil Engineer.)

[Continued from Page 252.]

### X.

### *Observations on the results of the Experiments.*

The great velocity of the wheel, hindering our counting its revolutions by the eye, we arranged hard by a key-wedge, a spring-blade, which it struck at each turn, and two observers, guided by the sound, counted at the same time the number of turns made in one minute, repeating the experiments several times to ensure accuracy.

The total fall was measured for each experiment by the simultaneous observation of two floats, one placed above in the trough, and the other below in the lower basin. These floats, graduated, and marked at fixed points, were placed in little cases, and in situations suitable to protect their indications from the influence of undulations of the level (or waves.) The float below served also to determine the depth to which the lower ring of the *turbine* was immersed.

All these arrangements being made, we proceeded to the execution of the experiments, of which the results are recorded in the following table :

*Experiments made in May,* 1837, *on the Turbine of the Power Weaving Establishment of Moussay, (Department of Vosges.)*

| Number of the experiments. | *Lift* of the sluice-gate of the Turbine. | *Charge* of water on the sill, or edge, of the *water-board*, 2.682 metres in breadth. | *Weight* of water expended per sec. | *Total fall.* | Absolute Work or Power expended by the Motor. No. of kilogrammes lifted one metre in one second. | Absolute Work or Power expended by the Motor. No. of horses-power of 75 kilogrammes lifted one metre in one second. | *Load* of the *Brake*, or Friction Dynamometer. | *Turns* of the wheel in *one minute*. | *Velocity* that the point of suspens'n of load tended to take in 1 *second*. | Useful effect measr by the Brake, or quantity of available force. No. of kilogrammes lifted one metre, in one second. | Useful effect measr by the Brake, or quantity of available force. No. of horses-power lifted one metre, in *one second*. | *Ratio* of *Useful Effect* meas'd. by *Brake* to the total power expended by Motor. | *Depth* which the *Turbine* was immersed, measured above *lower ring*. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | Metres | Metres | Kil. | Mtrs. | Kilog. | Hrs. pr. | Kilg. | No. | Mtrs. | Kilog. | Hrs. pr. |  | Mtrs. |
| 1 | 0.0500 | 0.179 | 362 | 7.091 | 2567 | 34.25 | 7.50 | 255 | 66.81 | 501 | 6.68 | 0.195 | 0.307 |
| 2 | 0.0490 | 0.179 | 362 | 7.056 | 2554 | 34.18 | 10.50 | 240 | 62.88 | 659 | 8.78 | 0.258 | 0.302 |
| 3 | 0.0465 | 0.179 | 362 | 7.160 | 2592 | 34.52 | 12.50 | 222 | 58.16 | 726 | 9.68 | 0.280 | 0.303 |
| 4 | 0.0500 | 0.184 | 372 | 7.255 | 2697 | 35.96 | 12.50 | 243 | 63.67 | 795 | 10.60 | 0.295 | 0.303 |
| 5 | 0.0500 | 0.1815 | 364 | 7.229 | 2624 | 35.00 | 15.50 | 228 | 59.74 | 925 | 12.33 | 0.352 | 0.301 |
| 6 | 0.0500 | 0.181 | 363 | 7.131 | 2588 | 34.51 | 17.50 | 221 | 57.90 | 1013 | 13.31 | 0.353 | 0.301 |
| 7 | 0.0500 | 0.1755 | 349 | 6.927 | 2419 | 32.26 | 20.50 | 210 | 55.02 | 1128 | 15.02 | 0.466 | 0.201 |
| 8 | 0.0470 | 0.185 | 373 | 7.127 | 2659 | 35.46 | 22.50 | 190 | 49.78 | 1120 | 14.93 | 0.420 | 0.296 |
| 9 | 0.0480 | 0.1755 | 349 | 7.313 | 2551 | 34.02 | 25.50 | 190 | 49.78 | 1267 | 16.89 | 0.497 | 0.295 |
| 10 | 0.0480 | 0.179 | 360 | 7.239 | 2606 | 34.75 | 27.50 | 178 | 46.64 | 1281 | 17.08 | 0.496 | 0.296 |
| 11 | 0.0480 | 0.176 | 351 | 7.294 | 2553 | 34.04 | 30.50 | 168 | 44.02 | 1342 | 17.89 | 0.525 | 0.294 |
| 12 | 0.0480 | 0.176 | 351 | 7.134 | 2504 | 33.39 | 32.50 | 163 | 42.71 | 1387 | 18.49 | 0.553 | 0.294 |
| 13 | 0.0480 | 0.174 | 345 | 7.034 | 2427 | 32.36 | 35.50 | 153 | 40.09 | 1423 | 18.97 | 0.586 | 0.294 |
| 14 | 0.0480 | 0.175 | 348 | 6.854 | 2384 | 31.78 | 37.50 | 152 | 39.82 | 1492 | 19.89 | 0.626 | 0.294 |
| 15 | 0.0470 | 0.187 | 378 | 7.395 | 2795 | 37.27 | 40.50 | 146 | 38.25 | 1547 | 20.62 | 0.553 | 0.293 |
| 16 | 0.0510 | 0.188 | 387 | 7.375 | 2854 | 38.05 | 42.50 | 152 | 39.82 | 1691 | 22.54 | 0.593 | 0.293 |
| 17 | 0.0510 | 0.184 | 375 | 7.087 | 2657 | 35.43 | 47.50 | 135 | 35.37 | 1667 | 22.22 | 0.627 | 0.293 |
| 18 | 0.0500 | 0.181 | 366 | 6.911 | 2529 | 34.05 | 52.50 | 108 | 29.30 | 1486 | 19.80 | 0.587 | 0.287 |
| 19 | 0.075 | 0.230 | 523 | 7.278 | 3807 | 50.76 | 32.50 | 240 | 62.88 | 2044 | 27.25 | 0.587 | 0.395 |
| 20 | 0.072 | 0.233 | 534 | 7.333 | 3914 | 52.20 | 37.50 | 228 | 59.74 | 2238 | 29.84 | 0.572 | 0.360 |
| 21 | 0.079 | 0.235 | 540 | 7.105 | 3837 | 51.16 | 42.50 | 227 | 59.47 | 2528 | 33.70 | 0.659 | 0.353 |
| 22 | 0.073 | 0.235 | 540 | 7.285 | 3934 | 52.45 | 47.50 | 207 | 54.23 | 2574 | 34.32 | 0.654 | 0.350 |
| 23 | 0.073 | 0.227 | 515 | 7.150 | 3682 | 49.06 | 52.50 | 173 | 45.33 | 2378 | 31.70 | 0.643 | 0.348 |
| 24 | 0.071 | 0.226 | 523 | 6.951 | 3635 | 48.46 | 57.50 | 150 | 39.30 | 2260 | 30.12 | 0.622 | 0.342 |
| 25 | 0.071 | 0.228 | 520 | 6.986 | 3633 | 48.44 | 62.50 | 138 | 36.16 | 2257 | 30.08 | 0.621 | 0.342 |
| 26 | 0.071 | 0.225 | 522 | 7.017 | 3633 | 48.84 | 67.50 | 120 | 31.44 | 2119 | 28.25 | 0.578 | 0.341 |
| 27 | 0.071 | 0.224 | 512 | 7.019 | 3594 | 47.92 | 72.50 | 106 | 27.77 | 2015 | 26.86 | 0.561 | 0.341 |
| 28 | 0.071 | 0.222 | 502 | 7.002 | 3515 | 47.00 | 77.50 | 98 | 25.68 | 1984 | 26.45 | 0.563 | 0.341 |
| 29 | 0.071 | 0.224 | 512 | 6.994 | 3579 | 47.72 | 82.50 | 84 | 22.01 | 1816 | 24.20 | 0.506 | 0.343 |
| 30 | 0.071 | 0.227 | 515 | 7.046 | 3629 | 48.38 | 87.50 | 76 | 19.91 | 1742 | 23.20 | 0.480 | 0.342 |
| 31 | 0.071 | Measurement by waste-board omitted. | 525 | 7.522 | 3948 | 52.64 | 42.50 | 222 | 58.16 | 2472 | 32.95 | 0.626 | 0.256 |
| 32 | 0.071 |  | 527 | 7.562 | 3984 | 53.12 | 52.50 | 201 | 52.66 | 2765 | 36.86 | 0.696 | 0.256 |
| 33 | 0.071 |  | 527 | 7.563 | 3985 | 53.13 | 62.50 | 158 | 41.40 | 2587 | 34.49 | 0.651 | 0.255 |
| 34 | 0.071 |  | 527 | 7.554 | 3979 | 53.03 | 72.50 | 130 | 34.02 | 2466 | 32.88 | 0.623 | 0.264 |
| 35 | 0.071 |  | 529 | 7.554 | 3920 | 52.30 | 82.50 | 102 | 26.72 | 2204 | 29.39 | 0.561 | 0.264 |
| 36 | 0.071 |  | 527 | 7.556 | 3979 | 53.05 | 92.50 | 80 | 20.96 | 1939 | 25.85 | 0.486 | 0.282 |

## *Experiments at Moussay—Continued.*

| Number of the experiments. | *Lift* of the sluice-gate of the *Turbine.* | *Charge* of water on the sill, or edge, of the *waste board,* 2.682 metres in breadth. | *Weight* of water expended in *one second.* | *Total fall.* | Absolute Work or Power expended by the Motor. | | *Load* of the *Brake,* or Friction Dynamometer. | *Turns* of the wheel in *one minute.* | *Velocity* that the point of suspens'n of the load tended to take *per sec.* | Useful Effect measured by the Brake, or quantity of available power. | | *Ratio* of *Useful Effect* meas'd. by *Brake,* to total power expended by the Motor. | *Depth* which the *Turbine* was immersed, measured above *lower ring.* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | No. of kilogrammes lifted one metre in one second. | No. of horses-power of 75 kilogrammes lifted one metre in one second. | | | | No. of Kilogrammes lifted one metre in one second. | No. of horses-power lifted one metre in one second. | | |
| | Mtrs. | | Kilo. | Mtrs. | Kilog. | Hrs. pr. | Kilo. | No. | Mtrs. | Kilog. | Hrs. pr. | | Mtrs |
| 37 | 0.086 | Measurement by waste-board omitted, and quantities of water calculated by the co-efficients of discharge of the Turbine ori-fices. | 616 | 7.421 | 4571 | 60.94 | 42.50 | 250 | 65.50 | 2784 | 37.11 | 0.609 | 0.352 |
| 38 | 0.086 | | 618 | 7.476 | 4622 | 61.63 | 52.50 | 220 | 57.64 | 3024 | 40.32 | 0.655 | 0.342 |
| 39 | 0.086 | | 620 | 7.484 | 4638 | 61.80 | 62.50 | 184 | 48.21 | 3013 | 40.16 | 0.650 | 0.334 |
| 40 | 0.086 | | 620 | 7.498 | 4649 | 61.99 | 72.50 | 155 | 40.61 | 2944 | 39.25 | 0.634 | 0.320 |
| 41 | 0.086 | | 620 | 7.503 | 4657 | 62.09 | 82.50 | 128 | 33.14 | 2734 | 36.45 | 0.586 | 0.305 |
| 42 | 0.086 | | 620 | 7.511 | 4664 | 62.19 | 92.50 | 108 | 28.30 | 2617 | 34.89 | 0.562 | 0.287 |
| 43 | 0.107 | | 729 | 6.779 | 4943 | 65.90 | 42.50 | 250 | 65.50 | 2784 | 37.11 | 0.562 | 0.974 |
| 44 | 0.107 | | 730 | 6.858 | 5008 | 66.77 | 52.50 | 240 | 62.88 | 3302 | 44.03 | 0.657 | 0.9 0 |
| 45 | 0.107 | | 732 | 6.911 | 5058 | 67.44 | 62.50 | 208 | 54.50 | 3406 | 45.41 | 0.673 | 0.887 |
| 46 | 0.107 | | 736 | 6.942 | 5115 | 64.87 | 72.50 | 169 | 44.29 | 3212 | 42.82 | 0.662 | .856 |
| 47 | 0.107 | | 736 | 6.950 | 5115 | 64.87 | 82.50 | 144 | 37.73 | 3110 | 41.87 | 0.640 | 0.848 |
| 48 | 0.107 | | 738 | 6.965 | 5137 | 68.49 | 92.50 | 122 | 31.96 | 2957 | 39.40 | 0.560 | 0.835 |

### *Observations on the foregoing Table.*

*In the experiments from* 31 *to* 48 *inclusive,* we had removed the wasteboard, to enable us to use the whole of the ordinary fall.

*In the experiments from* 37 *to* 42 *inclusive ;* to calculate the quantity of water emitted in *one second,* we took 0.86 for the coefficient of the discharge due to the orifices of the *turbine.*

*In the experiments from* 43 *to* 48 *inclusive ;* to calculate the volume of water emitted in *one second,* we took 0.83 for the cofficient of discharge due to the orifices of the *turbine :* and we had increased the depth, to which the turbine was submerged, by a stop-gate in the tail-race (so as to flood it with back water).

[NOTE.—Instead of the name *Friction Dynamometer,* we shall, hereafter, use its synonyme, *Brake.*—Trans.]

## XI.

## *Discussion and graphic representation of the results contained in this Table.*

To examine and discuss the results contained in this table, we have constructed the curves below, of which the abscisses are the number of turns made by the wheel in *one minute,* and the ordinates represent the ratios of the useful effect measured by the *brake,* or of the available work, to the total power expended by the *motor.*

In tracing the curves through all the points thus determined for each series in the best possible way to represent the whole of the results, we have obtained one prolonged graphic law, free from the accidental irregularities of the observations. It is by the aid of an examination of these curves that we shall discuss the results of the experiments.

The curve, Fig. 1, Plate I, which relates to the series where the lift of the *sluice-gate* was at a mean 0.050 metres, or $\frac{16}{100}$ of a foot, shows that the maximum of effect corresponded to a velocity of 135 turns in *one minute*, and that then the ratio of the useful effect, to that of the total power of the motor, was equal to about 0.61, although the calculation, based on the corresponding experiment, had given 0.625. But we see that from the velocity of 100 turns, to that of 170 turns per minute, this ratio has always been comprised between 0.565 and 0.610, so that even within these wide limits, it has not varied more than $\frac{1}{13}$th of its mean value, 0.587.

The curve, Fig. 2, Plate I, relating to the series of experiments where the lift of the *sluice-gate* of the *turbine* was 0.071 metres, or $\frac{23}{100}$ of a foot, shows that the maximum effect corresponded to the velocity of 190 turns in *one minute*, and that then the ratio of the useful effect, to the total power of the motor, was equal to 0.680, although the calculation, based upon experiment, had given 0.696. We see also that from the velocity of 130 turns, to that of 230 turns in *one minute*, this ratio has always been comprised between 0.625 and 0.680; so that even between these wide limits, it has varied only about $\frac{1}{12}$th of its mean value, 0.652.

The curve, Fig. 3, Plate I, relates to the series where the lifts of the sluice-gate of the turbine had been 0.086 metres, or $\frac{28}{100}$ of a foot, and 0.107 metres, or $\frac{35}{100}$ of a foot; these we have united to obtain a more correct trace, but we have distinguished the points of each by particular signs. This curve shows that the maximum effect corresponded to a velocity of from 180 to 190 turns in *one minute*, and that then the ratio of the useful effect, to the total power of the motor, was equal to 0.690. We see also that from the velocity of 140 turns, to that of 230 turns in *one minute*, this ratio has always been comprised between 0.650 and 0.690; so that between these wide limits it varied only $\frac{1}{17}$th of its mean value, 0.675.

It evidently follows from this discussion, that this wheel possesses the very remarkable and advantageous property of moving at extremely different velocities without much variation in its useful effect.

## XII.

### *Observations on the advantage which this wheel possesses of being able to move at very different velocities (without much variation of useful effect.)*

In many manufactures the velocity of the tool, and, consequently of the working point, must vary with the degree of forwardness of the work, and as it is always of importance to realize the maximum effect due to each case, the signal advantage of the turbine for such works is evident. But it is not less in those where the velocity is required to remain constant, even though the height of the available fall should vary considerably, either from the depression of the upper level, or the exhaustion of the lower; for the velocity of the wheel corresponding to the maximum effect depending on the total height of this fall, it follows that to obtain this maximum, we must contrive that the velocity of the wheel shall vary with the fall, but this, by hypothesis, the nature of the manufacture does not permit; whilst, by the property which these *turbines* have of being able to move at velocities very different from that which corresponds to the maximum effect, without the useful effect differing much from this limit, we see that with it we shall be able always to give to the tools, the velocity proper for the work, without losing any considerable part of the power of the motor. We shall see, by experiments, reported farther on, that this constancy of the useful effect held good for falls very different from those of Moussay.

## XIII.

### *Remarks relative to the experiments in which the wheel was entirely submerged by backwater.*

We shall observe also that in the experiments recorded in the preceding table, the level of the water below, rose, for the first series, to (0.300 m.) $\frac{98}{100}$ of a foot, above the lower ring of the turbine, and for the last series, to near (a metre) $3\frac{28}{100}$ feet, and that, nevertheless, the useful effect observed in this last series, has not been less, though the backwater was greater, than in the preceding. This result confirmed those which have been observed on the turbine of Moal, and shows again, that these wheels can move, when immersed, without their useful effect being sensibly diminished by the resistance of the water which surrounds them.

## XIV.

### *Observation on the increase of the useful effect in proportion as the lift of the sluice-gate augments.*

We shall now observe that the useful effect is perceptibly greater for those lifts of the sluice-gate which approach to the height of the turbine, than for those which are less; but as this effect is exhibited in a way more evident in the experiments made at Müllbach, we reserve the explanation of it for that part of the subject. Nevertheless, we shall remark, that with a lift of the sluice-gate of $\frac{16}{100}$ of a foot (0.05 m.), nearly half of the height of the turbine, the useful effect is about 0.61 of the absolute work, or power, expended by the motor, and it approached more nearly to the value 0.69, when the lift reached (0.107 m.) $\frac{35}{100}$ of a foot, (or nearly the whole height of the *turbine.)*

## XV.

### *Summary of the results drawn from these experiments.*

1. That the wheel of the weaving establishment of Moussay, which had but about (0.85 m.) $2\frac{79}{100}$ feet of external diameter, and (0.11 m.) $\frac{36}{100}$ feet of height of ring, under a fall of (7.50 m., or 24 $\frac{61}{100}$ feet,) is able to vent a volume of water of (0.738 cub. m.) $26\frac{04}{100}$ cub. feet in

a second; and, moreover, that it then transmitted *a useful effect, or available power, of more than* 45 *horses, each equal to* (75 kil. lifted 1 m. in 1 sec.) 32,553 *lbs. lifted one foot high in a minute.* [Which is so nearly the same as the *horse-power* of Boulton and Watt's steam standard, that it may be taken as identical therewith, which will be hereafter understood whenever the phrase *horse-power* is used.—Tr.]

2. That with the velocity of 180 to 190 turns in a minute, it returned, in available power, 0.69 of the absolute power expended by the motor, (or the *effect* produced, was to the *power* expended, as 0.69 to 1.)

3. That the velocity of the wheel may vary within very wide limits, without the useful effect abating more than $\frac{1}{12}$th to $\frac{1}{15}$th of its maximum value.

4. That the ratio of the useful effect to the power expended, does not diminish, when the wheel is submerged by backwater.

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## *Experiments on the Turbine of the Power Weaving Establishment of Müllbach (Lower Rhine).*

### XVI.

### *Summary Description.*

The power weaving establishment constructed in 1837, at Müllbach, in the department of the lower Rhine, has, for its motor, a *turbine* of about (2 m.) $6\frac{56}{100}$ feet in diameter; the mean power of which ought to be 45 horses. In compliance with my request, the intelligent proprietors, the Messrs. Sellière, Heevoot & Co., readily consented to make all the arrangements necessary for submitting this wheel to experiment. M. Schedecker, their partner, director of the spinning factory of Lutzelhausen, and also of this, willingly took upon himself to make suitable preparations; and on the 28th, 29th, and 30th of last July, the experiments were made in presence of M. Schedecker, M. Fourneyron, and several manufacturers and civil engineers.

The turbine is situated at the end of the canal of supply, in a chamber of (6.55 m. by 5.70 m.) $21\frac{49}{100}$ feet by $18\frac{70}{100}$ feet, in the floor of which is placed the cylinder which contains the sluice-gates. A hollow pipe which rises vertically, supports, by its lower extremity, the plate on which the curved guides are fixed, and it joins, by its upper extremity, to the apparatus which serves for raising the sluice-gate, and which receives the supports of the end of the lying shaft.

The shaft of the turbine enters within this cylinder, and passes out by the top, where it receives a beveled wheel, which transmit the motion to the lying shaft of the workshop, into which this shaft enters a little below the ground floor.

The *turbine* is placed below the floor of the water chamber, so that when this chamber is full, we cannot see either the sluices, or the wheel. The canal of escape, of which the direction is perpendicular to that of the canal of supply, has (6.40 m.) 21 feet of breadth, and is arched over for (20 m.) $65\frac{62}{100}$ feet beyond the building of the factory, under which it passes.

The work is fed by the waters of the Brasche, and the total fall is usually (4.50 m.) $14\frac{76}{100}$ feet; but at the time when these experiments were made, the stop-gate, which ought to withdraw the waters of the river into the canal of supply, was not yet executed, and the greatest fall of which we had the power to dispose, was only (3.70 m.) $12\frac{14}{100}$ feet. In freshets, the wheel becomes immersed, and it was so during all the experiments, to a depth which varied from about (0.520 m.) $1\frac{71}{100}$ feet, to (0.90 m.) $2\frac{95}{100}$ feet.

## XVII.

### *Gauge of the expenditure of water.*

To operate easily and accurately in gauging the expense of water, we had established at the end of the arch of the canal of escape, a stop-gate with an overfall, or waste-board, of (5.014 m.) $16\frac{45}{100}$ feet in breadth, of which the sill, or edge, formed by a thin plank of (0.027 m.) one inch thick, was (0.50 m.) $1\frac{64}{100}$ of a foot, to (0.60 m.) $1\frac{97}{100}$ of a foot from the bottom, and of which the vertical sides were each at (0.70 m.) $2\frac{30}{100}$ feet from the borders of the canal. The horizontal lines of reference established with care, admitted of easily measuring, at each experiment, the height of the level of the reservoir from (0.60m.) $1\frac{97}{100}$ of a foot upwards, and in the angles of the canal above the sill. From these circumstances of the establishment of this waste-board, or overfall, and the results of recent experiments made at Toulouse, and of which a part has been published by M. d'Aubuisson, we have taken to calculate the discharge of water in *one second*, the formula,

$$^{*}\ Q=0.41\ LH\sqrt{2gH},$$

[which differs but a trifle from that already employed; see article VIII.—Trans.]

But the water chamber having its bottom, and one of its sides, of wood, the wood drying by the heat of the season, and not having time to swell sufficiently, since it was filled (with water,) leaked considerably at the joints, and this it was necessary to take into account. This we did at the beginning of each series of experiments, by observing the depth of water on the waste-board of the gauge, when the sluices of the turbine were closed. The results of these observations are shown in the table of the experiments, and the volume of water thus lost, has been deducted from that which corresponds to the charge observed on the waste-board during the experiments.

## XVIII.

### *Arrangements made to measure the principal results.*

For obtaining the total fall, we arranged a horizontal line of reference, at a known height, above the plane of the sluices upwards,

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* I believe I ought to make the remark, that in those experiments, which I have published before, on the breast-wheel of the slitting mill of Balcarat, I have adopted the formula,

$$Q=0.395\ LH\sqrt{2gH},$$

not knowing then of the experiments at Toulouse, this induced me to estimate the discharge at about 1.26th below its value.

from which we measured simultaneously the height of the water above, in the chamber of the turbine, and the height below, in the canal of escape. The difference gave, for each experiment, the available fall, and the excess of the height of the line of reference above the plane of the sluices, over the elevation of the same line above the water below, gave the depth to which the lower ring of the turbine was immersed.

## XIX.

### *Of the Brake employed.*

The brake was formed by a pulley of (1.25 m.) $4\frac{10}{100}$ feet in diameter, and of about (0.25 m.) $\frac{82}{100}$ of a foot broad at the throat, which had been turned with care, and well centred and wedged upon the upper part of the shaft of the turbine, which had not yet received the gearing which belonged there. The two jaws of this brake were of wood; the length of the lever measured perpendicularly to the direction of the cord to which the charge was suspended, was (2.99 m.) $9\frac{81}{100}$ feet. A cord fixed to the top of the wood work at (6 to 7 m.) $19\frac{63}{100}$ to $22\frac{97}{100}$ feet high, sustained the ends of the lever, and a plumb line indicated the position which it ought to preserve, so that its length should be perpendicular to the direction of the cord, which passed over a fixed pulley, sustaining the load.

## XX.

### *Precautions to insure the regularity of the movement.*

To maintain the surfaces in the same state of humidity, we introduced near the wheel, the fire engine of the establishment, and a watering pot was suspended above the cushion of the brake, in which a notch was made, whence the water poured on it. The men, in working the pump, directed a constant and regular current upon the rubbing surfaces, which were thus continually cooled and lubricated to the same degree. We obtained, in this manner, such regularity in the action of the brake, that, when under the same charge, it has sometimes moved more than one half hour without the least oscillation, so that the workman who superintended it, was not obliged to alter its screws. In one of the experiments, which we report, the oscillations of the lever below the vertical of the plumb-line, had not exceeded (0.02 to 0.03 m.) $\frac{6}{100}$ to $\frac{8}{100}$ of a foot either way, and the stay pieces disposed as a precaution, acted only during the moments of interruption.

We have not used a kilogramme of grease in making all these experiments, and, although I had frequently employed this dynamometrical apparatus with success, I had never seen it move with such perfect regularity.

Thus aided by these easy and very available means, I consider as entirely useless superfluities, all the modifications proposed, or adopted, by divers engineers, in the simple arrangement originally proposed by M. de Prony.

## XXI.

### *Observations on the velocity of the Wheel.*

The observations on the velocity of the wheel have been made almost always by two persons, and by repeated trials, by counting with second-watches, the number of turns made in *a minute*, by the shaft of the wheel.

The results of the experiments, and those that we deduce from them by calculation, are recorded in the following table.

### *Observations on the following Table.*

*In the experiments from* 1 *to* 18 *inclusive;* the depth of water on the sill of the waste-board, arising from leakage, was 0.0265 m., which corresponds to *a loss of water of* 0.039 *cubic metres in a second,* which we have deducted from the volume which passed the waste-board during the experiments. It is the weight of the volume remaining, which is indicated by the fourth column.

*In the experiments from* 19 *to* 45 *inclusive;* the depth of the water on the sill of the waste-board, arising from the leakage, was 0.037 m., which corresponds to *a loss of water of* 0.064 *cubic metres in a second,* which we have deducted from the volume which passed the waste-board during these experiments.

*In the experiments from* 46 *to* 49 *inclusive;* the depth of the water on the sill of the waste-board, arising from leakage, was 0.038 m., which corresponds to *a loss of water of* 0.067 *cubic metres in a second,* and in the 46th experiment, it passed, besides in discharging 0.011 cubic metres in a second. These volumes expended, *in pure loss,* have all been deducted from those which passed the waste-board during the experiments.

*In the experiments from* 50 *to* 84 *inclusive;* the depth of the water on the sill of the waste-board, arising from leakage, was 0.038 m., which corresponds to *a loss of water of* 0.067 *cubic metres in a second,* which we have deducted from the volume of water which passed the waste-board during the experiments.

### *Experiments made in July,* 1837, *on the Turbine of the Power Weaving Establishment of Müllbach, in the Department of the Lower Rhine.*

| Number of the experiments. | Lift of the Sluice-gate. | Depth of water on the sill of the Waste-board, 5.014 m. in breadth. | Weight of water expended in one second. | Total Fall. | Absolute Power expended by the Motor. |  | Load of the Brake. | Turns of the Wheel in one minute. | Velocity which the point of susp'n. of load tended to take per second. | Useful Effect measur'd by the Brake, or quantity of available Power. |  | Ratio of Useful Effect measured by the Brake, to the total power of the Motor. | Depth the Turbine was immersed, measured above the lower ring. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  | No. of kilogrammes lifted one metre in one second. | No. Horses-power. |  |  |  | No. of kilogrammes lifted 1 metre in 1 second. | No. Horses-power. |  |  |
|  | Mtrs. | Mtrs. | Kilog. | Mtrs. | Kilog. | Hrs. pr. | Kilog. | No. | Mtrs. | Kilog. | Hr. pr. |  | Mtrs. |
| 1 | 0.050 | 0.174 | 622.5 | 3.552 | 2208 | 29.44 | 8.13 | 72.0 | 22.54 | 183 | 2.44 | 0.083 | 0.520 |
| 2 | “ | 0.174 | 622.5 | 3.547 | 2209 | 29.44 | 13.13 | 67.9 | 21.26 | 278 | 3.70 | 0.126 | “ |
| 3 | “ | 0.174 | 622.5 | 3.560 | 2213 | 29.51 | 18.13 | 64 8 | 20.48 | 371 | 4.93 | 0.167 | “ |
| 4 | “ | 0.174 | 622.5 | 3.580 | 2226 | 29.68 | 23.13 | 63.1 | 19.74 | 457 | 6.09 | 0.205 | “ |
| 5 | “ | 0.174 | 622.5 | 3.580 | 2226 | 29.68 | 28.13 | 60.0 | 18.80 | 429 | 7.00 | 0.238 | “ |
| 6 | “ | 0.174 | 622.5 | 3.565 | 2214 | 29.52 | 33.13 | 57.6 | 18.05 | 598 | 7.63 | 0.252 | “ |
| 7 | “ | 0.172 | 611.0 | 3.555 | 2170 | 28.93 | 38.13 | 55.3 | 17.35 | 662 | 8.82 | 0.306 | “ |
| 8 | “ | 0.172 | 611.0 | 3.565 | 2184 | 29.12 | 43.13 | 53.3 | 16.75 | 722 | 9.62 | 0.331 | “ |
| 9 | “ | 0.172 | 611.0 | 3.580 | 2187 | 29.16 | 48.13 | 50.7 | 15.90 | 765 | 10.20 | 0.350 | “ |
| 10 | “ | 0.173 | 610.0 | 3.585 | 2193 | 29.24 | 53.13 | 47.6 | 14.90 | 792 | 10.88 | 0.357 | “ |
| 11 | “ | 0.173 | 610.0 | 3.621 | 2208 | 29.44 | 58.13 | 43.9 | 13.76 | 800 | 10.99 | 0.373 | “ |
| 12 | “ | 0.173 | 610.0 | 3.621 | 2208 | 29.44 | 63.13 | 40.9 | 12.80 | 808 | 10.77 | 0.367 | “ |
| 13 | “ | 0.173 | 610.0 | 3.650 | 2223 | 29.64 | 68.13 | 37.5 | 11.72 | 798 | 10.64 | 0.360 | “ |
| 14 | “ | 0.173 | 610.0 | 3.680 | 2247 | 29.96 | 73 13 | 34.25 | 10.70 | 785 | 10.46 | 0.350 | “ |
| 15 | “ | 0.174 | 622.5 | 3.703 | 2301 | 30.34 | 78·13 | 31.0 | 9.70 | 758 | 10.10 | 0.332 | “ |
| 16 | “ | 0.174 | 622.5 | 3.725 | 2315 | 30.87 | 83.13 | 28.1 | 8.80 | 732 | 9.75 | 0.315 | “ |
| 17 | “ | 0.174 | 622.5 | 3.730 | 2322 | 30.96 | 88.13 | 26.85 | 8.32 | 733 | 9.77 | 0.316 | “ |
| 18 | “ | 0.174 | 622.5 | 3.750 | 2219 | 26.92 | 93.13 | 21.7 | 6.80 | 667 | 8.89 | 0.296 | “ |
| 19 | 0.090 | 0.262 | 1156. | 3.224 | 3727 | 49.69 | 35. | 75.0 | 23.26 | 814 | 10.85 | 0.218 | 0.926 |
| 20 | “ | 0.253 | 1087. | 3.199 | 3479 | 46.38 | 50. | 69.0 | 21.60 | 1080 | 14.40 | 0.311 | 0.926 |
| 21 | “ | 0.254 | 1101. | 3.208 | 3432 | 47.09 | 60. | 65.0 | 20.36 | 1221 | 16.28 | 0.346 | 0.877 |
| 22 | “ | 0.250 | 1071. | 3.210 | 3438 | 45.84 | 70. | 61.6 | 19.30 | 1351 | 18.01 | 0.392 | 0.875 |
| 23 | “ | 0.250 | 1071. | 3.196 | 3420 | 45.60 | 80. | 59.2 | 18.55 | 1484 | 19.78 | 0.432 | 0.874 |
| 24 | “ | 0.250 | 1071. | 3.177 | 3417 | 45.33 | 90. | 56.0 | 17.52 | 1577 | 21.02 | 0.462 | 0.875 |
| 25 | “ | 0.245 | 1036. | 3.190 | 3305 | 44.06 | 100. | 52.0 | 16.29 | 1629 | 21.72 | 0.492 | 0.875 |
| 26 | “ | 0.241 | 1016. | 3.190 | 3241 | 43.21 | 110. | 49.2 | 15.42 | 1696 | 22.61 | 0 523 | 0.865 |
| 27 | “ | 0.241 | 1016. | 3.207 | 3250 | 43.44 | 120. | 45.25 | 14.19 | 1703 | 22.70 | 0.524 | 0.870 |
| 28 | “ | 0.241 | 1016. | 3.207 | 3258 | 43.44 | 130. | 41.0 | 12.82 | 1667 | 22.22 | 0.512 | 0.870 |
| 29 | “ | 0.240 | 1008. | 3.215 | 3236 | 43.15 | 140. | 37.2 | 11.64 | 1630 | 21.72 | 0.504 | 0.875 |
| 30 | “ | 0.240 | 1008. | 3.225 | 3244 | 43.25 | 150. | 35.0 | 10.95 | 1643 | 21.90 | 0.506 | 0.875 |
| 31 | “ | 0.236 | 971. | 3.265 | 3162 | 42.16 | 160. | 32.5 | 10.26 | 1642 | 21.88 | 0.520 | 0.865 |
| 32 | “ | 0.236 | 971. | 3.305 | 3209 | 42.78 | 170. | 29.5 | 9.25 | 1573 | 20.96 | 0.490 | 0.865 |
| 33 | “ | 0.237 | 976. | 3.295 | 3190 | 42.53 | 180. | 27.5 | 8.61 | 1550 | 20.66 | 0.485 | 0.865 |
| 34 | 0.150 | 0.354 | 1881. | 3.164 | 5952 | 79.36 | 20. | 99.5 | 31.10 | 622 | 8.29 | 0.105 | 0.960 |
| 35 | “ | 0.349 | 1786. | 3.164 | 5648 | 75.30 | 40. | 92.0 | 29.10 | 1164 | 15.52 | 0.205 | 0.960 |
| 36 | “ | 0.345 | 1781. | 3.150 | 5543 | 73.90 | 60. | 90.0 | 28.15 | 1689 | 22.52 | 0.305 | 0.960 |
| 37 | “ | 0.343 | 1751. | 3.153 | 5513 | 73.50 | 80. | 83.5 | 26.10 | 2088 | 27.84 | 0.378 | 0.940 |
| 38 | “ | 0.342 | 1747. | 3.110 | 5433 | 72.44 | 100. | 78.5 | 24.55 | 2455 | 32.73 | 0.453 | 0.955 |
| 39 | “ | 0.337 | 1766. | 3.070 | 5424 | 72.32 | 120. | 73.0 | 28.05 | 3366 | 44.88 | 0.621 | 0.965 |
| 40 | “ | 0.331 | 1666. | 3·070 | 5124 | 68.32 | 140. | 69.0 | 21.60 | 3024 | 40.32 | 0.591 | 0.965 |
| 41 | “ | 0.326 | 1641. | 3.075 | 5046 | 67.28 | 160. | 63.0 | 19.70 | 3152 | 42.03 | 0.624 | 0.965 |
| 42 | “ | 0.322 | 1586. | 3.035 | 4731 | 63.08 | 180. | 58.25 | 18.25 | 3285 | 43.80 | 0.696 | 0.965 |
| 43 | “ | 0.320 | 1576. | 3.085 | 4863 | 64.84 | 200. | 52.0 | 16.29 | 3258 | 43.44 | 0.671 | 0.955 |
| 44 | “ | 0.318 | 1561. | 3.085 | 4816 | 64.21 | 220. | 48.0 | 15.01 | 3302 | 44.03 | 0.685 | 0.955 |
| 45 | “ | 0.312 | 1526. | 3.085 | 4703 | 62.70 | 240. | 44.0 | 13.79 | 3172 | 42.28 | 0.675 | 0.855 |

## *Experiments at Müllbach—Continued.*

| Number of the experiments. | Lift of the Sluice-gate. | Depth of water on the sill of the Waste-board, 5.014 m. in breadth. | Weight of Water expended in one second. | Total Fall. | Absolute Power expended by the Motor. No. kilogrammes lifted one metre in one second. | Absolute Power expended by the Motor. No. Horses-power. | Load of the Brake. | Number of Turns of the Wheel in one minute. | Velocity which the point of suspens'n. of the load tended to take in 1 second. | Useful Effect measured by the Brake, or quantity of available Power. No. kilogrammes lifted one metre in one second. | Useful Effect measured by the Brake, or quantity of available Power. No. Horses power. | Ratio of Useful Effect measured by the Brake, to the total power of the Motor. | Depth the Turbine was immersed, measured above the lower ring. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mtrs | Mtrs | Kilog. | Mtrs. | Kilog. | Hrs. pr. | Kilog. | No. | Mtrs. | Kilo. | Hrs. pr. | | Mtrs. |
| 46 | 0.150 | 0.331 | 1652. | 3.380 | 5583 | 74·44 | 260. | 45.3 | 14.20 | 3692 | 49.22 | 0.662 | 0.865 |
| 47 | " | 0.313 | 1528. | 3.272 | 5000 | 66.66 | 280. | 38.0 | 11.89 | 3329 | 44.38 | 0.666 | 0.850 |
| 48 | " | 0.313 | 1528. | 3.400 | 5187 | 69.16 | 280. | 38.5 | 12.05 | 3374 | 44.98 | 0.651 | 0.950 |
| 49 | " | 0.313 | 1528. | 3.405 | 5192 | 69.22 | 300. | 34.4 | 10.79 | 3337 | 43.16 | 0.626 | 0.820 |
| 50 | 0.200 | 0.380 | 2053. | 3.020 | 5857 | 78.09 | 10. | 104. | 32.55 | 326 | 4.34 | 0.055 | 0.890 |
| 51 | " | 0.377 | 2033. | 3.045 | 6186 | 82.48 | 20. | 103. | 32.25 | 645 | 8.60 | 0.104 | 0.890 |
| 52 | " | 0.375 | 2025. | 3.080 | 6237 | 83.16 | 40. | 101.5 | 31.75 | 1270 | 16.93 | 0.203 | 0.890 |
| 53 | " | 0.373 | 2003 | 3.120 | 6256 | 83.41 | 60. | 95. | 29.70 | 1782 | 23.76 | 0.280 | 0.890 |
| 54 | " | 0.371 | 1993. | 3.170 | 6332 | 84.42 | 80. | 90.4 | 28.25 | 2260 | 30.13 | 0.357 | 0.890 |
| 55 | " | 0.371 | 1993. | 3.190 | 6357 | 84.76 | 100. | 87.1 | 27.15 | 2715 | 36.20 | 0.426 | 0.885 |
| 56 | " | 0.365 | 1951. | 3.203 | 6249 | 83.32 | 120. | 82.8 | 25.90 | 3108 | 41.44 | 0.496 | 0.885 |
| 57 | " | 0.361 | 1913. | 3.240 | 6198 | 82.64 | 140. | 80. | 25.00 | 3500 | 46.66 | 0.565 | 0.885 |
| 58 | " | 0.361 | 1913. | 3.255 | 6227 | 83.02 | 160. | 75. | 23.48 | 3737 | 50.09 | 0.604 | 0.885 |
| 59 | " | 0.361 | 1913. | 3.270 | 6255 | 83.40 | 180. | 70. | 21.96 | 3942 | 52.56 | 0.632 | 0.880 |
| 60 | " | 0.361 | 1913. | 3.305 | 6313 | 84.17 | 200. | 67.6 | 21.16 | 4232 | 56.42 | 0.671 | 0.880 |
| 61 | " | 0.361 | 1913. | 3.310 | 6331 | 84.41 | 200. | 67.1 | 21.90 | 4200 | 56.00 | 0.664 | 0.870 |
| 62 | " | 0.353 | 1872. | 3.310 | 6182 | 82.42 | 220. | 63. | 19·70 | 4334 | 57.78 | 0.702 | 0.870 |
| 63 | " | 0.353 | 1872. | 3.335 | 6228 | 83.04 | 240. | 58. | 18.15 | 4356 | 58.08 | 0.700 | 0.870 |
| 64 | " | 0.349 | 1812. | 3.306 | 5991 | 79.88 | 260. | 50.6 | 15.84 | 4118 | 54.91 | 0.686 | 0.884 |
| 65 | " | 0.349 | 1812. | 3.286 | 5960 | 79.46 | 280. | 48.5 | 15.16 | 4245 | 56.59 | 0.712 | 0.884 |
| 66 | " | 0.349 | 1812. | 3.321 | 6017 | 80.23 | 300. | 44. | 13.79 | 4137 | 55.16 | 0.690 | 0.884 |
| 67 | " | 0.392 | 2173. | 3.610 | 7860 | 104.80 | 90. | 100. | 31.25 | 2813 | 37.50 | 0.357 | 0.640 |
| 68 | " | 0.383 | 2082. | 3.650 | 7615 | 101.53 | 110. | 97. | 30.30 | 3339 | 44.51 | 0.440 | 0.640 |
| 69 | " | 0.388 | 2143. | 3.560 | 7643 | 101.90 | 130. | 91. | 28.50 | 3705 | 49.40 | 0.485 | 0.640 |
| 70 | " | 0.384 | 2083. | 3.475 | 7253 | 96.70 | 150. | 87. | 27.20 | 4080 | 54.40 | 0.562 | 0.680 |
| 71 | " | 0.378 | 2061. | 3.300 | 6815 | 90.87 | 170. | 80. | 25.03 | 4255 | 76.70 | 0.626 | 0.680 |
| 72 | " | 0.371 | 1983. | 3.250 | 6458 | 86.11 | 190. | 72. | 22.60 | 4312 | 57.79 | 0.670 | 0.680 |
| 73 | " | 0.367 | 1943. | 3.230 | 6289 | 83.85 | 210. | 67. | 20.90 | 4389 | 58.52 | 0.700 | 0.680 |
| 74 | " | 0.364 | 1933. | 3.358 | 6505 | 86.73 | 230. | 62.1 | 19.43 | 4379 | 58.38 | 0.676 | 0.557 |
| 75 | " | 0.360 | 1908. | 3.343 | 6392 | 85.23 | 240. | 57.5 | 18.00 | 4500 | 60.00 | 0.703 | 0.557 |
| 76 | " | 0.356 | 1863. | 3.392 | 6317 | 84.23 | 270. | 54. | 16.90 | 4563 | 60.84 | 0.721 | 0.557 |
| 77 | " | 0.356 | 1863. | 3.398 | 6337 | 84.49 | 290. | 49.4 | 15.46 | 4483 | 59.77 | 0.785 | 0.557 |
| 78 | 0.270 | 0.432 | 2523. | 3.290 | 7562 | 100.82 | 170. | 90.6 | 28.19 | 4592 | 61.22 | 0.609 | 0.750 |
| 79 | " | 0.432 | 2523. | 3.070 | 7758 | 103.44 | 190. | 87. | 27.20 | 5168 | 68.90 | 0.670 | 0.750 |
| 80 | " | 0.422 | 2442. | 3.170 | 7760 | 103.47 | 210. | 84.6 | 27.50 | 5565 | 74.20 | 0.721 | 0.750 |
| 81 | " | 0.422 | 2442. | 3.180 | 7750 | 103.33 | 250. | 77.25 | 24.20 | 6050 | 80.66 | 0.785 | 0.750 |
| 82 | " | 0.422 | 2442. | 3.310 | 8097 | 107.96 | 290. | 69. | 26.50 | 6264 | 83.52 | 0.760 | 0.720 |
| 83 | " | 0.432 | 2523. | 3.475 | 8776 | 117.01 | 330. | 66.1 | 27.20 | 6831 | 91.08 | .707 | 0.720 |
| 84 | " | 0.423 | 2445. | 3.390 | 8302 | 110.69 | 340. | 61.5 | 28.19 | 6545 | 87.26 | 0.793 | 0.720 |

## XXII.

### *Graphic representation and discussion of the results contained in the preceding Table.*

To examine and unite the results contained in this table, we have the same as for the experiments on the turbine of Moussay, constructed curves having for abscisses the number of turns of the wheel in one minute, and for ordinates the ratio of the useful effect, to the total power of the motor.

The curve, Fig. 4, Plate I, relating to the series where the lift of the sluice-gate was (0.050 m.) $\frac{16}{100}$ of a foot, shows that, for this small lift, the useful effect rose only to 0.37 of the total power of the motor, and that from the velocity of 33 turns in a minute, to that of 51 turns, it was comprised between 0.35 and 0.37, so that between these wide limits, it varied but $\frac{1}{36}$th of its mean value.

The curve, Fig. 5, Plate I, relating to the series where the lift of the sluice-gate was (0.090 m.) $\frac{29}{100}$ of a foot, shows that the useful effect rose in this series to 0.725 of the total power of the motor, and that from the velocity of 26 turns in a minute, up to that of 55 turns, it was always comprised between 0.680 and 0.725, so that between these wide limits, it did not vary more than $\frac{1}{32}$nd of its mean value, 0.702.

The curve, Fig. 6, Plate I, relating to the series where the lift of the sluice-gate was (0.150 m.) $\frac{49}{100}$ of a foot, shows that the useful effect rose, in this series, to 0.690 of the total power of the motor, and that, from the velocity of 35 turns in a minute, to that of 65 turns, the useful effect was always comprised between 0.630 and 0.690, so that between these wide limits, it did not vary more than $\frac{1}{22}$nd of its mean value, 0.660.

The two curves, Fig. 7, Plate II, relating to the series where the lift of the sluice-gate was (0.200 m.) $\frac{65}{100}$ of a foot, refer, the lower one, to the series where the turbine was submerged (0.88 m.) $2\frac{89}{100}$ feet, and the upper one, to the series where it was so, but (0.64 m.) $2\frac{10}{100}$ feet. Their examination shows that, even to the velocity of 60 turns in a minute, the ratio of the useful effect to the total power of the motor, is the same for the two series, and rises for the case of the maximum to 0.710. We see further, that for the first series, from the velocity of 40 turns in a minute, up to that of 66 turns, this ratio has been constantly comprised between 0.675 and 0.710; so that even between these wide limits, it did not vary more than $\frac{1}{39}$th of its mean value, 0.692.

For the second case where the wheel was submerged only (0.64 m.) $2\frac{10}{100}$ feet, the ratio of the useful effect, to the total power of the motor, diminished less rapidly in proportion as the velocity augmented; and it remained comprised between the same limits of 0.675 to 0.710, from the velocity of 40 turns in a minute, to that of $72\frac{1}{2}$ in a minute.

The curve, Fig. 8, Plate II, relating to the series where the lift of the sluice-gate, was (0.270 m.) $\frac{88}{100}$ of a foot, shows that the ratio of the useful effect, to the absolute power of the motor, was, at the maximum, 0.79, and that from the velocity of 55 turns in a minute, to that of 79 turns, it was always comprised between 0.775 and 0.790; so that even between these wide limits, it varied only $\frac{1}{97}$th of its mean value, 0.780.

After having examined particularly the results relative to each of the series of experiments, if we cast a glance over the whole, we see immediately that the ratio of the useful effect, measured by the brake, to the total power of the motor, is only 0.37 at the maximum for the first series, a result much inferior to those we had obtained for it in the other series. For explaining this difference, it appears to me proper to relate an observation, which I have had occasion to make, on the introduction of the water along a curved bucket of a form analogous to those of the turbines.

When we introduce by the outer border of a curved bucket, carried in its movement of rotation about a vertical axis, a filament of water possessing a certain velocity, as soon as the liquid reaches the surface of the buckets its velocity is altered, not only by the action of the centrifugal force which tends to remove it from the axis, but also by the adhesion which it contracts with the surface. The fluid vein becoming thin, rises along the bucket to a height the greater in proportion to the first velocity; it follows hence, that the relative velocity of the liquid is altered by two causes, and that a considerable portion of the active force of the liquid is consumed by its adhesion to the partition: moreover, if, as in the turbines, the buckets are short, and little raised, a part of the liquid can lose another portion of its velocity against the upper ring, whilst the other part, actuated by an ascending velocity, escapes to the outside, preserving a vertical velocity which it would not have acquired, if the buckets had not had a height equal to that of the filament of water. This shows besides, that the diminution of the useful effect in the case of small lifts of the sluice-gate, belongs to circumstances of this species, because we see the useful effect increases in proportion as the difference between the lift of the gate and the height of the turbine diminishes.

In effect, as soon as the height of the sluice-gate reaches (0.09 m.) $\frac{29}{100}$ of a foot, the useful effect becomes equal to about 0.71 of the total power of the motor, and for the stronger lifts which come near the height of the wheel, it reaches the value of 0.79 of the total power. The experiments, moreover, showed that for the discharges (of water) which varied from 1500 to 2500 kilogrammes in one second, the ratio of the useful effect, to the absolute power of the motor, is sensibly the same within these wide limits.

## XXIII.

### *Observations relative to the experiments when the wheel was submerged.*

We shall observe that the series of experiments relative to the lift of the sluice-gate of (0.200 m.) $\frac{66}{100}$ of a foot, where the wheel was only immersed from (0.64 m. to 0.56 m.) $2\frac{10}{100}$ to $1\frac{84}{100}$ feet, had given results more advantageous than those in which the depth of immersion was increased to (0.88 m.) $2\frac{89}{100}$ feet, as soon as the velocity had exceeded 60 to 65 turns in a minute. This effect ought, without doubt, to be attributed to this, that, in the second case, the mass of water to which the wheel communicated a gyratory movement, was greater than in the first, and, that the rubbing surface of the buckets was submitted to a greater pressure; but the velocity of the wheel, suitable to the maximum of effect, being comprised between 45 and 65 turns in a minute, it follows that within the common limits of these velocities, this difference in the depth of immersion has no important influence on the useful effect.

The last series of experiments, relative to a lift of the sluice-gate of (0.270 m.) $\frac{88}{100}$ of a foot, has given us a useful effect at the maximum of 91 horses, although the wheel had been constructed only for 45 to 50 horses, and we regretted not being able to push the experiments further, by increasing the load on the brake; but the cast-iron shaft of the turbine, having been proportioned only for a power of 40 to 45 horses, at a velocity of 50 to 60 turns in a minute; after having nearly doubled the load which it was meant to carry, we had not the courage to go further, from the fear of occasioning some permanent twist.

### XXIV.

### *Conclusions from these Experiments.*

1. That the turbine of the power-weaving establishment of Müllbach, which was only about (2 m.) $6\frac{56}{100}$ feet diameter, and (0.333 m.) $1\frac{09}{100}$ feet in height, could, under a fall of from (3.50 m. to 3.75 m.) $11\frac{48}{100}$ feet to $12\frac{30}{100}$ feet, expend a volume of water $88\frac{3}{10}$ cubic feet, or 2.5 cubic metres in a second, transmitting, then, *a useful effect, or available power, of* 91 *horses.*

2. That, at a velocity of 50 to 60 turns in a minute, and with a strong lift of sluice-gate, it rendered in *useful effect,* 0.78 *of the total power expended by the motor.*

3. That the velocity of the wheel could vary within very wide limits without the useful effect abating more than from $\frac{1}{25}$ to $\frac{1}{50}$ of its maximum value.

4. That the ratio of the useful effect, to the total power of the motor, did not diminish when the wheel was immersed about (1 m.) $3\frac{28}{100}$ feet, if it moved with a velocity not much exceeding that which belonged to the maximum of effect when it *was not* immersed.

5. That the expense of water having varied from 1500 to 2500 kilogrammes in a second, that is to say, in the ratio of 3 to 5, the ratio of the useful effect, to the total power, remained sensibly the same.

(To be continued.)

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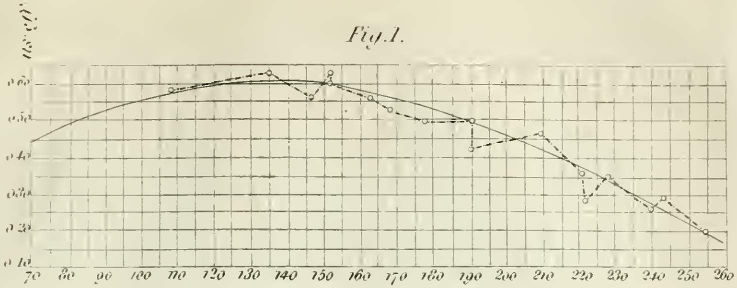
## *Mr. Vignoles' Lectures on Civil Engineering, at the London University College.*

(Continued from Page 251.)

### LECTURE XV.—WORKING EXPENSES OF RAILWAYS *(continued.)*

Having, in the last lecture, analyzed the working expenses of railways, in reference to the train, that is, reduced to a rate per train per

Fig. 1.



1st Series ○ 2nd Series ×

Fig. 2.

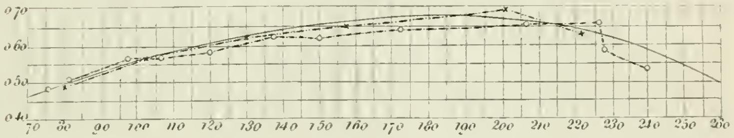


Fig. 3.

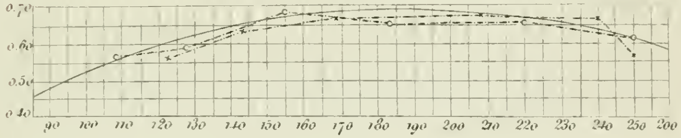


Fig. 4.

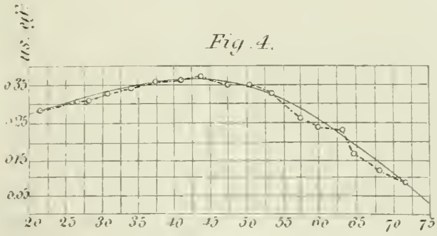


Fig. 5.

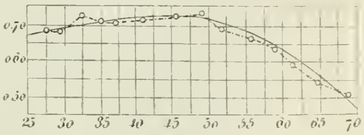
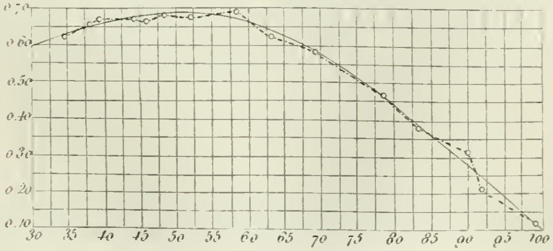


Fig 6



mile, with an average load at the usual velocity, the Professor considered it might be well to consider the same subject in another light. In the preceding mode of calculation, no regard was paid to the amount of what might be called the useful weight carried. It seemed to the Professor, that the proportion between the dead weight of the engine, tender, and carriages, and the weight of the passengers and their luggage—in short, between the unprofitable and the profitable load—formed an important element for consideration, even if it did not affect the principle on which railways ought to be worked. In the common omnibus, with a full complement of passengers, the proportion was one to one—taking the average load, about five to three—or, including the weight of the horses (the moving power which has also to carry itself), about three to one, or, with a full load of passengers, something less than two to one. But, on the railway, owing to the far greater weight of the carriages, and general arrangement on most lines, the proportion of dead weight is much greater. In a first class carriage, as adapted for long lines, and fully loaded with passengers and their luggage, the proportion is two and a half to one; but, taking the average load, it is about four to one, and, when but little luggage is taken, four and a half and five to one. On short lines, where the trains run often, with many carriages, the proportion is sometimes as high as eight to one, or, including engine and tender, as twelve to one. In an ordinary train of about seven carriages, their weight, and that of the engine and tender, may be taken at about fifty tons; the average number of passengers, has, on a former occasion, been shown to be about sixty per train, or four tons without, and, perhaps, five tons with, their ordinary weight of luggage, and say one or two tons of packages and parcels paying freight, being a proportion of six or seven of unprofitable, to one of profitable load; and if the carriages were all full, about four and a half or five to one, as above, and, on the average, the proportion might very fairly be taken as at least five to one. It appeared to the Professor that there was some radical error here, and that some arrangements were wanting to reduce this proportion, as far as the carriages were concerned, for, of course, as long as the locomotive engine was used, its weight would always form a large proportion of the load, particularly with light trains—though the carriages certainly required to be made strong and heavy on this system—and this seemed an inherent defect on this principle of locomotion, perhaps quite irremedial. Yet, at all events, on many lines the proportion of dead weight of carriages was much too great, and might be remedied. Of late this had been done on the Greenwich Railway, where, by combining two classes of seats in the same vehicle, much fewer carriages sufficed. There was a great contrast to this on the Blackwall Railway, where, from having a separate carriage for each station, according to the peculiar mode of working that line, the proportion of dead carriage weight was generally about three, and often four, times as much as on the Greenwich, though the carriages were of the same build. Owing to this and to other causes, extra guards, rope, &c., notwithstanding the generally admitted economy of stationary power, the expense of working the Blackwall Railway, per train per mile, was double what the Professor found was the average for the working on several locomotive lines, and quite as high, if not higher, than the present rate of working on the Brighton Railway, which was the highest of any that had yet come under his cognizance. Although, abstractedly, this over proportion of dead weight carried, was not always connected with the moving power, yet an engineer ought to point out, and, when within his control, to remedy such an evil, as the loss consequent on carrying useless weight is equivalent to that arising from increased resistance of gravity in surmounting an unnecessary ascent—a case which every engineer is naturally anxious to avoid.

In the mode of reducing railway expenses to a mileage, adopted in the last lecture, the number of passengers, and their proportion to dead weight of carriages, had not been considered, for it was clear that the arrangement of carriages in any train being supposed to be duly proportioned to the average traffic, any addition to the average assumed load would be pure profit, and would not cause any sensible addition to the cost of the transit of the regular load, for which all the necessary arrangements of engines, tenders, carriages, guards, stations, and the whole working and carrying establishment of the railway was already provided and paid for. But, suppose another mode of considering the working expenses be adopted, viz., from the number of passengers in a train, deduced from an average of many lines for several years, or from any assumed number per train, let the cost per passenger per mile be worked out, and this will lead to the consideration of the true policy for attracting the greatest number of persons, and trying to fill the trains up, as they must go, at any rate.

The Professor then went through the various items of railway expenses stated in the former lecture, and brought them out in decimals of a penny per passenger per mile—the result being, that, taking account of experience gained and applied, and economical arrangements duly introduced, the expense of locomotive power might be taken at ¼*d.* per passenger per mile, which was coming back to the original estimate made for the working of the London and Birmingham Railway. Other expenses, including government duty, would bring the total up to two-thirds of a penny, and, under favorable circumstances, of well filled carriages, this might sometimes be brought down to ½*d.*, but taking the average of lines as now worked, the cost was about 1*d.* per passenger per mile. On many of the American railways the cost was as low as ½*d.*, and for long lines on the continent, in India, &c., where wages were low, and coal or wood might be got very cheap for locomotive fuel, and no rates, or taxes, on profits and passengers were laid, the charge of carrying passengers per mile might be fairly taken at ½*d.* only. Now, if the proportion between the unprofitable and the profitable parts of the load were reduced to three to one, as regarded carriages only, and six to one as regards the whole weight of the train, the expense of carrying passengers, taken by weight, will be still at least three times as expensive as carrying goods only at the same velocity, the proportion being of wagons to goods as two to three, and of the whole train, including engine and tender, at less than two to one, and with heavy trains, of goods only, about one to one, and for coal and mineral traffic, at diminished rates of traveling, still less. The Professor observed, that the cost of conveying merchandize might be taken at about 1*d.* per ton per mile for railway expenses only, exclusive of collection and distribution at the termini of lines, and that of coal and minerals at about ½*d.* per ton per mile. With these elements, therefore, of the expense of working railways either per train, or per passenger, or per ton, it is for the politic manager of a public concern to consider what should be the rate of charges above these cost prices to make to the public, so as to induce the greatest amount of traffic. Mr. Vignoles then observed, that there was a third way of considering the subject of the working expenses of railways, in reference to the number of engines employed, which was the mode adopted by the Irish Railway Commissioners, and which was, perhaps, the proper way of calculating the annual cost on lines of little intercourse, on which, however small the traffic might turn out to be, yet a certain number of engines must be kept to do any work at all. The commissioners in following out this inquiry, endeavored to determine the proportion the cost of locomotive power bore to the total working cost of a railway. For the Liverpool and Manchester line it was found that this proportion was only one-fourth the gross annual charges on that line, including much town carriage of goods collected and delivered; but on the Dublin and Kingstown Railway the proportion was, at that time, nearly one-half. It was observed by the Professor, in a digression, that for the average of railways it was now determined to be about one-third. The commissioners finally assumed the cost of locomotive power to be one-third of the total expense of working a line of mixed traffic, and that to run a given number of trains per day, a certain number of engines must be provided; it was then calculated that £1750 a year would be the cost of each engine to work about from 25,000 to 30,000 miles annually, and then they computed the amount of gross receipts necessary to cover those expenses and interest of capital. This was working backwards, to ascertain whether it is justifiable to make a railway at all in certain districts. The result of the commissioners' calculations were, that, supposing there went only two trains daily throughout a given line, the average load of each train ought to consist of either fifty tons of goods, or eighty passengers, or a mixed load of twenty-five tons of goods and forty passengers, or, in that proportion, in order to justify a line being made—the average charge for passengers being assumed each 1¼*d.*, or for goods 2*d.* per ton per mile, which, it may be observed, is scarcely the half of the average rates of charge on the principal English railways. Mr. Vignoles observed, in conclusion, that having shown that the cost of conveyance of passengers, merchandize, minerals, &c., could be nicely calculated from the experience gained, and could be brought to the definite mileage rates before mentioned, *he thought the proper railway charge should be double the cost for working;* which, when the railways had been judiciously constructed, and without extravagance, would sufficiently remunerate the undertakers, as such moderate principle of charging would bring the most traffic.

(To be continued.)

## *Great Britain Steamer.*

By the politeness and favor of Mr. Guppy, the Engineer of the Company, we were permitted to inspect this celebrated vessel on Tuesday, the day previous to His Royal Highness Prince Albert's visit.

It is impossible for us, by any description we can give, to do justice to this great and noble ship. To form a true estimate of her, one must see her, go on board of her, and compare her with other vessels. Her upper deck, which is 308 feet long, and 50 wide, and flush throughout its entire length, appears to be a promenade, of which it would require some effort to march from one end to the other. From the figure-head to the taffrail is 322 feet.

Her grand saloon aft, is a noble room, 98 feet by 32, and near 8½ feet high. The fittings of this room are different from those of any other steamer we have yet seen. The style is extremely neat and chaste. About 8 feet from each side, and also in the centre line of the ship, are a row of pillars, some 10 or 12 feet apart, and opposite to each of these is a pilaster very tastefully ornamented, the intermediate spaces being panelled, so as to throw out the ornamented pilasters to the greatest advantage. At the ends and certain angles of the room, are placed mirrors, at such angles as to produce very pleasing illusions, and to have a fine effect.

Above this is the principal promenade saloon, which is decorated to correspond, and which also has a row of pillars down its centre. Ranged along its sides are seats for those who choose to lounge and sit, while the middle forms a light and spacious promenade in wet, or rough, weather.

In the fore part is another promenade cabin, or saloon, of less dimensions, being 67 by 21¾ feet, but intended, we hear, to be fitted up in a similar manner.

Beneath this, above the water-line, is the fore dining-room, which is 61 by 21¾ feet. There are 26 single bedded-rooms, and 113 double bedded.

For the accommodation of ladies there are large and commodious sitting-rooms communicating with their berths. These rooms, to the capacious size of which several berths are necessarily sacrificed, will be a great comfort to lady passengers, particularly in rough and foul weather.

We understand that the number of passengers' beds will be about 260. They might easily have made up a great many more, but have chosen to limit the number, rather than to encroach upon the comforts and pleasure of their customers, of which, indeed, they have been more prodigal than they might, with a just regard to their own profit.

The public has long been informed, that this vessel is to be driven by a propeller somewhat upon the principle of the screw. The plane of this propeller is at right angles to its shaft, which is about 8 or 9 feet above, and parallel to the keel. To speak popularly, it consists of four segments of fans, (frustrums of the screw spiral of 22 feet pitch) not plain, but twisted, so as to produce the best effect upon the water, the general plane of each being inclined in an angle to the plane of the propeller. The form, inclination, or pitch, and dimensions of the fans, we understand have been the result of long and careful experiment, made for the especial purpose of finding out the best form.

The diameter of the propeller is 16 feet, and its top will be under the water line when the vessel is loaded.

By dividing the propeller into four parts, it is calculated that the motion of the vessel will be easier, and that the water will not be so much sliced, as if there were a greater number of fans, and will hence be capable of offering more resistance.

The shaft of the propeller, which is of solid wrought-iron, 16 inches diameter, passes through a stuffing-box in the stern of the vessel, and terminates in a wheel, which is to be driven, as we understand, by a pitch chain passing over this and the great drum. This wheel is 6 feet, and the drum attached to the crank shaft of the engine is 18 feet diameter. The propeller, therefore, makes three revolutions for every revolution of the drum, or every double stroke of the engine.

The length of the stroke is 72 inches, and the diameter of each cylinder 88.

There are four cylinders, two placed on each side of the vessel, opposite, or nearly so, to each other, the opposite pairs converging towards the top in an angle of about 68 degrees. The connecting rods of each pair are attached to the same crank, and, therefore, drive the crank as one cylinder.

This plan simplifies the machinery much, and obviates a difficulty which had been conceived by some eminent steam navigation gentlemen, with regard to the simultaneous working of the cylinders in a rough sea. As designed, the four work as one pair.

It is intended to work the cylinders expansively, with an apparatus for cutting off the steam at any part of the stroke within certain limits. The intention is to cut off at one-fourth, and expand the other three-fourths. The computation is, that when the cut off is at half-stroke, each cylinder will do the duty of 250 horses, the steam in the boiler being 6 lbs. above the atmosphere. The engines are, therefore, collectively, of 1000 horse-power.

The boiler is 34 ft. long, 32 ft. broad, and 22 ft. high, and is divided into three nearly equal compartments, each compartment forming a separate boiler, and may be all three used separately, or together. These compartments add much to its strength. The steam-pipes from each compartment unite behind the boiler, and the steam-ways, 24 inches diameter, turn round the sides to the cylinders.

The boiler is heated by 24 fires, and its plates are 7-16th inch thick. The flues recurve within the boiler, and give it something of the property of a tubular boiler.

At present merely the boiler and cylinders are put in the vessel. The framing and truss-work for the shaft, &c., are of Demerara

Green Heart wood, and very thick wrought-iron, and present the appearance of great strength.

The rudder is 7 ft. wide, and works upon a pivot, of course, behind the propeller, two-thirds behind it and one-third before. It will, therefore, be very easily worked, and as the propeller will force the water back upon it with considerable force, it will possess great command over her motions, even at comparatively slow velocities. This is one great advantage the screw and all aft propellers have over paddles; the vessels are always more manageable with them.

At 6 lbs. per horse-power per hour, the *Great Britain* will consume 2.67 tons of coal per hour, or near 64 tons per day. To steam, therefore, for 20 days, she must carry 1,280 tons of coals. Her bunkers will contain 1,200 tons, or provision for about 19 days.

With regard to the vessel herself, she is, on all hands, allowed to possess the finest proportion, and most beautiful lines. Her neat entrance, clean run, and gracefully swelling sides, strike the eye as exceedingly well calculated for speed, steadiness of motion, and sitting well upon the water. From her great length, and apparently narrow beam, it might be expected she would be disposed to roll, but as her water line is below the swell of her sides, that will be a great check, and the probability is, that she will ride with greater safety, and be less liable to ship seas. She is calculated to average 12 knots an hour at the least, by steam, and with a good fair wind, 13 through the water. At this rate she will reach New York in 10 days.

It is intended to carry only one class of passengers, for which, as we said, every comfort and convenience are secured.

As our readers know, she is made of iron. Her plates and angle-irons, or those which would be called her ribs, are $\frac{5}{8}$ths of an inch thick. These are trussed with immense stringing timbers at every deck and division, and strengthened by struts from the iron joists supporting the decks. The lower decks themselves consist of narrow planks stretching from side to side, of 5 inches thick. These are again strengthened by cross-iron stays, screwed to them in all possible directions beneath. In fact, every care appears to have been exhausted to ensure ample strength and stability to this magnificent vessel.

The displacement of the *Great Britain* is about 3,200 tons. Her power, therefore, is one horse to 3.2 tons, which is a high proportion, especially for a vessel of her tonnage. Taking, consequently, into account her tonnage and power, they are warranted in calculating upon an unusually high speed.

Her engines and machinery weigh about 600 tons, and the total quantity of iron used in her, is 1,500 tons. The greatest care has been used to have none but materials, whether iron, or wood, of the very best quality.

She has 6 masts, 4 of which carry fore and aft sails only, and the main-mast, which is 75 feet high above the deck, will have an immense spread of square and studding sails.

She has 5 water-tight bulkheads, all reaching above the water-line, but some of them much higher. Her funnel is 39 ft. high, and 8 ft. diameter.

The estimate was for £75,000, but it is expected she will cost about £100,000. The weight of the main-iron shaft is 16 tons, the largest ever constructed. It was manufactured at the Mersey Iron Works. Her boiler will contain about 200 tons of water; and her pumps, worked by machinery, will be able to throw off 7,000 gallons of water a minute.

At the time we were at Bristol, we had an opportunity of going over the Company's work-shops, and were both surprised and pleased to observe the unusually fine manner in which they turn out their work—it is a credit to Bristol.

Railway Magazine.

## *The Steam Excavating Machine.*

We have already had the pleasure of introducing this important machine to the public, and we now avail ourselves of the opportunity of giving some further account of it. As is well known, it is of American invention: and this individual machine was imported from the United States, after having been employed on a railway there for the purpose of testing its capabilities in this country. It is now at work on the Eastern Counties Railway, about 20 mile from London, and is exciting much attention. In its present state, the machine is rather complicated, but it is susceptible of great improvement; and we have no doubt that any machines manufactured in this country will be much simplified. For this purpose it cannot be in better hands, the management of the patent being entrusted to Mr. John Braithwaite, the engineer, whose mechanical attainments are well known to the public, and who is well qualified to turn a machine of this kind to the best account.

The accompanying engraving* is a perspective view of the machine when at work, and it will be seen by it, that one man, the engine-tender, stands behind, to regulate the performance of the engine, and another man in front, to regulate the motion of the scoops, and to turn the jib, or crane, to the right or left, as may be required. By the aid of this jib, the scoop is enabled to take a sweep of 30 feet, and clear away obstructions before it to the height of about 14 feet.

The cubic content of the scoop is 1½ yard, and it lifts about 1¼ cubic yard, two of which is about a wagon load of 2½ cubic yards. If the wagons were brought up as fast as the machine could supply them, it would fill 30 per hour. During the day we inspected the machine, it loaded 26 wagons of 2½ cubic yards each within the hour; and at another performance, it filled 103 cars in 5½ hours. By these trials, the duty of the machine appeared to be, upon an average, 20 wagons, or 50 yards, per hour, or 500 yards per day. This quantity does not appear to be more than half the duty of the machine, as detailed in a report before us, emanating from a committee of managers of the American Institute, New York, especially appointed to examine the machine. The committee state—

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* See engraving in this Journal, page 324, vol. v.

"The excavator has been employed for three years upon the Western Railroad, and other places, and that this test showed an immense saving of expense. It is calculated to do the work of 150 men, and will fill cars as fast as they can be presented to receive their loads. Allowing for stoppages, one minute may be given as the average for filling a car of 1½ cubic yard. The interest for the cost of the machine, wear and tear, men's wages, fuel and oil, 13½ dollars, (about 2*l.* 16*s.*) but to cover the contingencies, say 20 dollars."

There is also another report, showing the daily performance of two machines employed for two months, in almost constant work, at Brooklyn, New York, during which period the two machines worked collectively 881 hours, and excavated and loaded 92,593 cubic yards of earth, equal to 105 cubic yards per hour, or 1080 cubic yards per day. The machines worked during the above period, upon an average, nearly ten hours per day, which is equal to the working hours of a man. The quantity which one navigator can remove, or "get and fill," in one day, is about ten cubic yards, or one cubic yard per hour; we have, therefore, the performance of one machine equal to 105 men, according to the statements of the American engineers.

We will now proceed to examine the comparative cost of working by the machine and manual labor. For this purpose we must calculate the power of the engine, which is called a 10 horse engine, but on account of the high pressure at which the steam is worked, it will be found equal to 34 horse effective piston power. The following are the particulars of the engine:

Diameter of cylinder 9 inches = 63.6 square inches.
Length of stroke, 1 foot; number of strokes per minute, 100 to 110 —say 200 feet per minute.
Pressure of steam, 90 to 100 lbs, per square inch—say 90 lbs.
Fuel—coke.

Then we shall have the engine-power $= \frac{63.6 \times 200 \times 90}{33{,}000} = 34.7$ horse-power on the piston, which, if taken in the same proportion as low condensing engines, the nominal power of which is taken at only 7 lbs. pressure, or about half the effective piston-power, we shall have the nominal power of the engine equal to 17 horses, the consumption of which may be taken at about 10 lbs. of coal, or 8 lbs. of good coke, per horse per hour, which will give, for the consumption of the above engine, $17 \times 8 = 136$ lbs. per hour, or 12 cwt. per day of 10 hours. If we take the cost of the coke at 35*s.* per ton, delivered at the works, we shall have the cost of the fuel 21*s.*, then the cost of working the machine per day may be stated thus:—

| | *s.* | *d.* |
|---|---|---|
| Coke, - - - - - - | 21 | 0 |
| Oil, tallow, &c., - - - | 2 | 0 |
| Engine tender, - - - | 6 | 0 |
| Man on the stage, - - - | 5 | 0 |
| 1 laborer assisting, - - - | 3 | 6 |
| Sundries, - - - - | 2 | 0 |
| Cost per day, - - | 40 | 0 |

This will be the cost for removing 500 cubic yards of earth, but exclusive of repairs, depreciation, interest on cost of machine. The cost of making one of the machines we estimate at 1200*l.* The cost of manual labor may be taken for "getting and filling," (see Journal vol. v, p. 187,) at 4½*d.* per cubic yard, then,

500 cubic yards at 4½*d.* = 9*l.* 7*s.* 6*d.*

We have here a difference of 7*l.* 7*s.* 6*d.* between the cost of engine and manual power; and if we make an allowance for the repairs of the machine, depreciation, interest, &c., 2*l.* per day, there will be a saving of 5*l.* 7*s.* 6*d.* We may, therefore, set down the actual cost of engine power at 2*d.* per yard, which would give 4*l.* 3*s.* 4*d.* per day, for 500 yards, thus clearly showing that the steam excavator must ultimately supersede manual labor, on account of its cost and rapidity in execution for all extensive cuttings, either for railways, canals, or docks; but if we make our calculations according to the report of the American engineers, allowing the duty of the machine to be 1050 cubic yards per day, the calculation will stand thus:—

| | £ | *s.* | *d.* |
|---|---|---|---|
| 1050 cubic yards by manual labor at 4½*d.* | 19 | 13 | 9 |
| Deduct—working of engine per day 2*l.*,<br>Repairs, depreciation, interest, &c., 2*l.* | 4 | 0 | 0 |
| Saving, - - - | 15 | 13 | 9 |

By this calculation the cost of excavation is not quite 1*d.* per yard.*

Civ. Eng. & Arch. Journ.

## *Woolen Factory for Turkey.*

Mr. Fairbairn exhibited a model, showing the plans, sections, and architectural elevation of a Woolen Factory, to be constructed of cast and wrought iron, near the town of Izmet (Turkey) for the Sublime Porte.

Mr. Fairbairn said that, in 1839, he visited Constantinople under the instructions of the late Sultan Mahomed, and reported upon nearly all the government works. Their extension was checked by the death of that prince, but the present Sultan was disposed to carry them into effect, and, by his orders, Mr. Ohanes Dadian had arrived in England, in furtherance of the plans for ameliorating the state of the Turkish community, by introducing useful arts and manufactures, in which he was aided by his Excellency Ali Effindi, the ambassador to the court of England, and the consul-general, Mr. Edward Zohrab. Almost all the houses, and many of the public buildings, in Turkey, being constructed of timber, destructive fires were frequent. In many parts of the country the common building materials were expensive; iron had, therefore, been resorted to for construction, and Mr. Fairbairn had already sent over an iron house for a corn-mill, 50 ft. long, 25 ft. wide, of three stories in height, and with an iron roof. It was finished in 1840, and erected at Constantinople in the succeeding year. The success of this attempt induced a second order, which was for an extensive woolen factory, to be composed entirely of cast-iron plates, the interior being formed throughout of brick arches, upon cast-iron columns and bearers, with an iron roof. He then described in detail, the construction of the different parts of the building, and the machinery, which would be driven by a fall of water of 25 ft. in height, of the computed average power of 180 horses. Several ingenious devices were described for preventing any objectionable effects from the high conducting power of the metal. The piers between the windows were hollow, so as to admit a current of air through during the hot season; and the iron roofs were so arranged as to have beneath them a coating of plaster, to serve as a non-conducting substance. The two principal rooms were described to be 272 ft. long, 40 ft. wide, and 20 ft. high; and 280 ft. long, 20 ft. wide, and 20 ft. high; with a great number of other rooms, for the several processes in the manufacture of coarse woolen cloths, for the counting-houses, and departments of the directors, and for the reception of the sultan, &c. The area of the enclosed surface, including the court-yard and buildings, was nearly 3 acres, or 110,621 square feet.

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* The above article is accompanied by letters from Mr. Whistler, the chief, and Mr. Swift, a resident, engineer, on the Western Railroad, in Massachusetts, during its construction, who speak very favorably of the actual working of these machines, in some heavy earth cuttings, on that railway, *during three years.*

Mr. Swift states, that upon one of the sections, "it excavated 19,000 cubic yards (of sand and gravel) in twenty-five working days, and 1000 yards per day were excavated for several days in succession."—Com. Pub.

The floor surface in the basement rooms = 16,480 square feet. Ditto in the upper rooms = 54,616 square feet. Ibid.

## *Legal Decision regarding Well-Sinking.*

In the Court of Exchequer Chamber in Error, on Wednesday, May 19, a judgment of considerable importance was pronounced by Lord Chief Justice Tindal, in the case of "Acton *vs.* Blundell." Within twenty years before the commencement of the action, the plaintiff had sunk a well, and the water which it collected was sufficient to work his mill; but in 1837, the defendant dug a coal-pit three-quarters of a mile distant, which, eventually, drained the well dry, and, therefore, an action was brought to recover compensation. On the trial, the judge told the jury, that if the defendant had dug the pit in the manner which was usual in working and winding a mine, he was justified by law in what he had done; and the jury found for the defendant. A bill of exceptions to this charge was presented, which had, subsequently, been argued, but the Court now decided that the summing up was correct. The Court were of opinion that the case should be decided on the principle of the rule which gave to the owner of the soil every thing under the surface of it; and that if the plaintiff had suffered loss by the exercise of the defendant's rights, it was a loss which was *damnosum non injuriosum,* and for which no action could be maintained. The Court, therefore, unanimously gave judgment for the defendant.

Ibid.

## *On a New Application of Railways.* By Ellwood Morris, C. E.

It is well known that prior to the introduction of the modern railway system, cities were chiefly furnished with provisions, from a space covered by the revolution of a very limited radius, whose length was determined by the distance which horses could travel within a few hours; while but very moderate supplies, indeed, were ever drawn from a greater distance than a day's drive.

An immediate result of the greatly augmented speed of travel, consequent upon the construction of any modern railway leading from a city into the interior of the country, is a direct and considerable extension of the surface, capable of becoming with advantage, *tributary to the market of that city.*

The large augmentation of the surface of production, tributary to any market consequent upon a diminished cost and increased speed of transport, must, inevitably, have an effect upon the value of provisions there, and it will follow, hence, that whenever the railway system shall be properly availed of, for the supply of our cities, the selling prices of country produce in their markets *must fall,* and their numerous inhabitants be thereby benefitted.

This is but another phase of the important economical revolution which the great iron roads of modern days are gradually producing in all that is, in any way, dependent upon the cost, or time, of carriage.

Upon the European railways the highest advantages seem to have been derived from the facilities they furnish for the cheap and easy carriage, from great interior distances, of live stock, and other provisions, destined for the supply of the overgrown communities there assembled in the great cities.

Even in our own country their influence, in the aspect referred to, is beginning to be strongly, as well as beneficially, felt, and one railroad corporation, at least, has profited considerably by the establishment of a market train, regularly drawn, like other freight, by locomotive steam power.

We refer to the Camden and Amboy Railroad Company, the directors of which, in their elaborate report of 1840, upon the completion of their works, describe the success that has attended the establishment of a regular market train upon their railway, which has been the means of opening, for the supply of the provision market of New York, a large district of country, practically inaccessible before.

In the report referred to, at page 11, we find the following statement:—

"Two years since, at the request of some market people in New Jersey, a line, called *the pea line,* with two cars, was occasionally started from Camden to New York, with no other view, or expectation, than the accommodation of a very useful and respectable class of men. This line has steadily increased until it has become profitable beyond all expectation. During the past year it has been running daily, sometimes taking with it as many as sixteen cars, laden, at the appropriate season, with peas, peaches, potatoes, asparagus, cabbages, live stock, and upon one occasion, (as incredible as it may seem,) *thirty tons of green corn!*"

The European railroads have been found extremely beneficial in the transportation of live stock, and other provisions, to the great cities, which have thus been enabled to draw their supplies from a much larger surface of country, and, consequently, at a smaller price.

Since the completion of the Baltimore and Ohio Railroad to Cumberland, extravagantly high prices can no longer be commanded for agricultural products on sale in the Baltimore markets; thus with the article of *butter,* it has been recently observed, that whenever it becomes unusually high, large quantities are promptly sent down by the farmers beyond Harper's Ferry, and prices fall at once.

So strong, indeed, is the influence of this railway in regulating, and keeping down to a moderate standard, the market prices of Baltimore, that it has already become a subject of complaint with those, who, from the nearness of their position, have heretofore been able to hold a monopoly of the supply.

Other facts might readily be adduced, which, in connexion with the remarkable experience of the Camden and Amboy Company, would show, in a striking light, the advantages which must follow the introduction of market cars upon railways, and will, ultimately, among other results, tend to soften the prejudices still entertained, by some, against railways, as aristocratic monopolies, since, by reducing the cost of the necessaries of life to all, they will recommend themselves, in the strongest manner, to a large majority of our population.

With the introduction of market trains upon railways, *provision depots* become desirable, and the first of these which has fallen under the notice of the writer, where provisions brought in railway cars are kept on sale, both wholesale and retail, is that lately erected in the city of Philadelphia, in connexion with the Columbia Railroad, and opened in June of this year, under the denomination of the *car market.*

It is this new application of railways—*to the formation of a railroad market*—that it is proposed briefly to describe.

The idea of constructing a *railway market,* having been for some time entertained by Mr. Samuel Webb, an intelligent and enterprising citizen of Philadelphia, who foresaw the advantages that must flow from the transportation of provisions by the railways centering upon that city; he applied to the writer during the past year, to work out the practical details, and superintend the construction of *a car market-house*, of which he furnished the outline.

This building has accordingly been erected: it was opened to the public in June last, and promises to be very successful.

The *car market* is 200 feet long, and 40 feet wide, it fronts on Schuylkill Seventh street, north of Callowhill, its axis being parallel to the State Railroad leading to Columbia, and 130 feet distant from the southern sideling.

In consequence of the position of the building, it was necessary to enter it through the north flank by reversed curves, with a short tangent between: this is effected by turning out of the Columbia Railway to the right, upon a curve of 80 feet radius, and $51\frac{1}{2}$° deflection, into a tangent running off obliquely at that angle; thence by this tangent 90 feet, and then by another curve of 80 feet radius, and $51\frac{1}{2}$° deflection, turning to the left we curve into the axis of the market-house.

Through the centre of this building longitudinally, from end to end, a straight track of railway is laid, and to enable the empty cars to pass out without interference, a return track is provided, which, by a radius of 48 feet turning $128\frac{1}{2}$° of curvature, re-enters the oblique tangent before mentioned.

All of these curves are laid with a common railway superstructure, and, though their radii are so very limited, they, nevertheless, answer their purpose satisfactorily.

The writer will here observe in passing, that for the ordinary entrance tracks of depots, a common railway superstructure, where all the wheels run upon their treads as usual, will answer very well when curved upon a radius of 80 feet, and of the numerous side tracks recently laid here, to accommodate the coal trade descending the Reading Railway, nearly all the curves are ordinary railroad tracks, and in some of them radii of curvature of less than 80 feet, have been adopted without inconvenience.

The car market is near 37 feet wide in the clear, and the stalls are made to project out 8 feet, at every 16 feet lineal of the walls, forming recesses between, and leaving a central promenade of 21 feet wide, entirely unincumbered, except by the pillars which carry the second floor.

This arrangement allows ample space for purchasers, even when the central railway is filled with cars, and by means of the projecting stalls, furnishes a great development of stall surface, for the exposure of provisions on sale.

The building is of stone, two stories high, and the second floor is destined, in the course of time, to be also used for the sale of the lighter articles of marketing, which, brought to the market in cars, will then be elevated to the next story, by some convenient means.

Such is the outline of an enterprize which will probably form a prototype for others on a more extended scale, *since, the idea acted upon, seems to be a sound one, and must, eventually, have a very* *important effect upon the provisioning of those cities, which, by their railways, command the interior country.*

Amer. Railroad Journal.

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FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

## *Cost of Transportation on Railroads.* By CHARLES ELLET, Jr., C.E.

(Continued from Vol. IV, page 367.)

The importance of ascertaining the expense of transportation on railroads, to a large portion of the population of this country, has led to many discussions, and many inquiries, with a view to its determination. No general method has, however, yet been produced, by which it can be ascertained with any tolerable degree of accuracy. The difficulty appears to have arisen, in a great measure, from the fact, that these expenses consist in a variety of elements, which increase and diminish in value by different laws, and at rates which depend on the combinations of these elements in each particular case. It has, also, to some extent, grown out of the fact, that during the progress of this system, every year has produced some new work of improvement, which has supplied new data to calculators—and, unfortunately, data which have preceded the effect of the two greatest causes of expenditure—the destruction consequent on use, and natural decay. Without referring to another difficulty—the extravagant estimates of the friends of particular projects, and, sometimes, the gross misrepresentations of the enemies of others—we see that the subject is much too complicated to be unraveled without close study, and mature reflection. To make a general solution, we have, obviously, to allow for differences of grade, differences of tonnage, differences between the amounts of travel, and have due regard to the length, and even the age of the improvement.

Now, to attempt to go through this whole subject, and produce and analyze the data on which are founded all my conclusions, would require much more labor, than I have a disposition, at this time, to appropriate to the question. What I now propose to do, is again to point out the LAW which governs railroad expenditures, and to fix, with greater accuracy, the values of the constant coefficients than was practicable when I first offered the formula which are here repeated.

It is my intention to submit, in the first place, the law which governs the expenditures on a *new road,* and attempt to offer a reasonable explanation, and a just estimate, of the difference between the expenses incident to a new road, and an old one. If my method be true, the reasons, and the values which I assign for this difference, must be obviously just. The general law must first satisfy the mind, and the rate of increase, in passing from a new to an old road, must likewise be rational and convincing. If, after this preparatory evidence, I bring forward a certain new road of great length, and show that the calculated cost corresponds well with the actual result, it will certainly be a strong confirmation of the general correctness of the method. But still, for a prudent man proposing to risk his fortune, this alone ought not to be sufficient. This particular example might be selected because it was accidentally found to suit the object; he would have a right, therefore, to call on me to produce a *short* road, and show that the results still correspond with my calculation. His intellect might not yet be fully satisfied; it would be fair for him to call for another example, in which the trade and travel were both unusually great, in order to be assured that the method is applicable to works of that character also; and, even after finding this result to be confirmatory of the method, extreme prudence would dictate an additional application to another road with very small trade.

All this appearing satisfactory, he could not well retain a doubt; but, when men stake their fortunes, and the comfort and indulgence of their families on the issue, they have a right—they are bound—to exercise great circumspection. Such a party might, therefore, well call for an application of the method to an *old road*—or to one that has arrived at maturity, at least,—in order to see whether his investment is likely to be permanently good.

If this doubt be also satisfied; if he finds that the application may be safely made to a road of this description; if, in addition, it is made to one of this sort with a great trade—next, to one with a small trade—then to one with great travel and no tonnage; afterward to a long one, and, finally, to a short one; to some roads with light, and to others with heavy grades—and, if he find that it gives consistent results in all these varied applications—as a reasonable, and as an intelligent man, he will be compelled to admit, that the method is in accordance with THE LAW, and that its results are the TRUTH.

It is such testimony that I propose to offer the reader, and I solicit his attention in order that he may judge fairly of my consistency—for consistency is a test of truth.

The following propositions are what I designate as Laws:—

I. The cost of motive power, with engines of the same class, is proportional to the distance which the engines run. The cost per mile is nearly the same on roads of all grades—the difference in expense on roads with different grades, consists not essentially in variations of the cost *per mile run*, but in variations of the number of miles which must be performed to do the same duty.

II. The repairs of the road, with equal trade, are proportional to its length; that is to say, *cæteris paribus*, it costs twice as much to keep up a road 200 miles long, as it does to maintain one in the same condition, of which the length is 100 miles; just as it costs twice as much to run engines 200,000 miles, as it would to run the same class of engines 100,000 miles.

III. The repairs of cars are proportional to the number of tons conveyed, and to the distance to which they are conveyed. It costs twice as much to repair cars which run two millions, as it does those which run one million of miles per annum. Again, it costs twice as much to repair cars which convey 20,000 tons a given distance, as it does those which convey 10,000 tons the same distance. The same principle applies equally to the conveyance of passengers; it applies also to accidents, incidentals, and contingencies—for these things increase with, and are proportional to, the increase of business.

These may appear like self-evident truths, and they are, in fact, so glaring that they scarcely appear to have been looked on at all. The custom now is to regard the expense of cars as proportional to the distance the *engine* runs. It is here made proportional to the distance the *cars* run. It is customary also to consider the repairs of the road as proportional to the distance traveled by the engine—whereas it is only proportional to the length of the road.

These are simple principles, and such as cannot well be doubted, or denied. It remains to state the values of the constants.

### *Repairs of Roads.*

The repairs of a railroad, I have stated, must be divided into two classes—those which are dependent on, and those which are independent of, the amount of the tonnage. Of the first division, the wear of iron depends entirely on the use, and the wear of the wood, but partially on the use. The rotting of timber, the cleaning out of ditches, the repairs of culverts, embankments, &c., are independent of the trade. But these items are not independent of *time;* the expenses of repairs increase but little until the wood in the sills, ties and rails, begins to decay, and require removal, when they usually soon attain their maximum, and afterward diminish, until they reach a second minimum.

The following table exhibits the cost of repairs on six of the most successful roads in this country, which I have purposely selected from different sections. The table embraces three roads of each of the two great classes—three wooden superstructures with plate rails, and three iron roads with T or H patterns.

By casting the eye down the columns, the progressive increase of expenses will be easily recognized. It must be borne in mind, however, that these numbers do not include the renewal of the iron—an item always charged to "extraordinary repairs," or "permanent improvements"—as though iron rails were ever permanent, or their destruction extraordinary. Eventually, the cost of the new iron passes into capital stock, or funded debt.

*TABLE showing the Increase of the Cost of Repairs of Railroads.*

| Year. | Permanent Roads—T Rail. | | | Wooden Roads—Flat Bars. | | |
|---|---|---|---|---|---|---|
| | Boston & Lowell. | Boston & Provid'ce. | Boston & Worcester | Utica & Schenec'y. | Petersburg Road. | S. Carolina Road. |
| 1836 | | | | | 251 | 870* |
| 1837 | 546 | 285 | 206 | 354 | 664 | 880 |
| 1838 | 611 | 411 | 281 | 330 | 542 | 1040 |
| 1839 | 731 | 209 | 405 | 450 | 539 | 982 |
| 1840 | 816 | 334 | 830 | 613 | 794 | 592 |
| 1841 | 1200 | 597 | 784 | 837 | 857 | 547 |
| 1842 | 1350 | 514 | 903 | 935 | | 503 |
| 1843 | | | | | | 375 |

I may add the following notes of the cost of motive power per mile traveled by the engines, which are extracted from documents that were not in my possession when I first stated the cost per mile for passenger engines at 25 cents, and of freight engines at 30 cents.

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* Finished in 1833, when the expenses were very low.

*TABLE showing the Cost of Locomotive Power for* 1842.

| Name of Road. | Miles run. | Expense. | Cost per mile. | Year | Remarks. |
|---|---|---|---|---|---|
| Boston and Providence. | 35,031 | $ 11,399 | $32\frac{1}{2}$ | 1842 | Freight engines. |
| Boston and Providence. | 77,774 | 23,352 | 30 | 1842 | Passenger engines. |
| Western Road. | 397,295 | 84,165 | $21\frac{1}{7}$ | 1842 | Exclusive of wages. |
| Western Road. | 397,295 | 115,000 | 30 | 1842 | Wages included. |
| Utica and Schenectady. | 155,828 | 33,454 | $21\frac{1}{2}$ | 1841 | Exclusive of new engines. |
| Utica and Schenectady. | 155,828 | 52,268 | $33\frac{6}{10}$ | 1841 | Including new engines. |
| Reading Road. | 83,717 | 17,443 | $20\frac{8}{10}$ | 1841 | With new engines. |
| Reading Road. | 198,055 | 49,800 | $25\frac{1}{4}$ | 1842 | New, but heavier, engines. |

This table entirely confirms the previous estimate (vol. iv, p. 307.) Another table in my possession (derived from reports of 1842) gives for the average value of repairs of locomotives, 7 cents per mile run; my impression is, however, that this item is worth not less than 8 cents, and that future observation will maintain it, for engines that are not fresh from the factory, at about that average.

We may now pass to the method and the rule which I propose for computing the aggregate annual expenses of a road. In the first numberof this investigation, I proposed a formula which was published in this journal, for determining the value of these expenses—stating, however, that there was no line in the country which had yet exhibited results as favorable as those expressed by that formula. The present paper is intended to show these expenses *as they are;* the same formula is used though the constants are modified to suit the actual condition of the system.

### *For new Roads.*

The aggregate annual charges on *new roads** are made up of the following items, viz.:—

For every mile traveled by the engines, 24 cents; for every ton conveyed one mile, 9 mills; for every passenger conveyed one mile, 7 mills; and for every mile in length of the road, 300 dollars, a fact which is expressed by the formula,

$$\frac{24}{100}N+\frac{9}{1000}T+\frac{7}{1000}P+300h.$$

Now, new engines consume as much, or nearly as much, fuel and oil as those which have been used; and they require the same number of enginemen and firemen. The only reduction in the cost of their maintenance, consists in the item of repairs. The bill for repairs for the first year or two, is only about one-half its mean value; and as the average cost of repairs is about 7 cents per mile run, the aggregate cost per mile run on a road which has passed its fourth year, should be $27\frac{1}{2}$ cents, instead of 24 cents.

The *timber* in the superstructure is worth, on the average, from 1000 to 1500 dollars per mile, and lasts from 5 to 7 years. The decay of timber in roads of mature age, is, therefore, about $200 per mile—so that ordinary repairs on such roads will be about $500 per mile.

The wear of cars after the road has been a few years in operation, is equivalent to about $4\frac{1}{2}$ mills per ton per mile; and on a new road it is scarcely appreciable. The difference between the perceptible injury to the road and cars, on a new and old road, is about 5 mills per ton per mile. The rule then is,—

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* I designate as *new*, roads less than five years old.

*For old Roads.*

For every mile traveled by the engines, (passenger engines 25 and freight engines 30 cents.) an average of 27½ cents; for every ton conveyed one mile, 14 mills; for every passenger conveyed one mile, 7 mills; and for every mile of road, $ 500.

If the principles and the values here offered be correct, they will stand the test of trial, and in order to make the test the strongest possible, I will add, in a subsequent paper, an estimate of the probable results on a road in active operation, and the subject of much speculation at the present time, the correctness of which estimate can be verified at the end of the year.

This rule, if applied to the business of a line in activity, will give only those expenses which are usually denominated "ordinary expenses." In order to arrive at the *true cost* of maintenance we have to add, of course, the extraordinary expenses, which we can likewise estimate with some, though not very great, accuracy, by data now supplied by the improvements of the country.

*Application of the formula to Active Works.*

I shall apply this method of computation, in the first place, to a railroad in Georgia, 147½ miles long, with easy grades and little business; next, to one in Massachusetts, 156 miles long, with grades of more than 80 feet to the mile, on which the engines travel nearly four hundred thousand miles per annum, and where the trade and travel are both great; I will then apply it to a short road in the State of New York, which carries no tonnage at all, but which derives its revenue entirely from passengers, and which has moderate grades, and a moderate business; next, I will make the application to a road in Maryland 70 miles long, with grades of 84 feet, and which derives two-thirds of its revenue from tonnage. Finally, I will apply it to a road in Pennsylvania 56 miles long, with favorable grades and moderate business—and again to the same road the next year, when extended 38 miles further, and having an increase of business.

The following table gives the length, grades and business of these roads; and, in the two last columns, are placed, side by side, the actual and calculated expenses.

*TABLE exhibiting the actual and computed cost of maintaining New Roads, calculated from the formula,*

$$\frac{24}{100}\,\mathrm{N} + \frac{9}{1000}\,\mathrm{T} + \frac{7}{1000}\,\mathrm{P} + 300h.$$

| Name of Road. | Length. miles. | G'de. in ft. | M. traveled by engines. | Thro' tonn'e. | Thro' travel. | Expenses. | Calculat'd expenses. | Year. |
|---|---|---|---|---|---|---|---|---|
| Georgia Road, | 147½ | 37 | 152,873 | 10,000 | 12,000 | $109,819 | $106,605 | 1842 |
| Western Road, | 156 | 83 | 397,295 | 40,000 | 53,000 | 256,619 | 256,187 | 1842 |
| Syracuse and Utica, | 53 | | 84,000 | | 70,769 | 62,325 | 62,315 | 1842 |
| Baltim'e & Susqueh'a. | 70 | 84 | 128,349 | 23,000 | 16,500 | 75,224 | 74,379 | 1842 |
| Reading Road, | 56 | 19 | 83,717 | 24,000 | 31,453 | 62,635 | 61,318 | 1841 |
| Reading Road, | 94 | | 193,055 | 65,000 | 33,720 | 138,900 | 152,911 | 1842 |

The roads named in this table are all those which have been completed less than four years, of which I have been able to procure the trade and travel, aggregate expenses, and distance run by the locomotive engines for the year 1842. In some of these I have been compelled to deduce the through tonnage from the receipts and prices —the reports giving only the aggregate tonnage ;—in general the through travel is given with precision.

The agreement between the actual and calculated results in this table, is most remarkable, and exhibits a degree of uniformity in the administration of the lines, which could not have been anticipated. Indeed it is most probably because the roads are so new that the agreement is so perfect. When they begin to feel the effects of time and use, they will give way unequally, and exhibit much wider deviations from the rule. This fact is exemplified in the following table, which exhibits the results of experience on ten important railroads, selected from different sections of the country. The roads in this table vary in length from 14 miles to 136 miles; in grades from 10 ft. per mile, to 83 ft. per mile; in freight from nothing to 94,000 tons; in travel from 7,000 to 180,000 passengers; and in expenses from 30,000 to 225,000 dollars per annum.

*TABLE exhibiting the actual and computed cost of maintaining roads which have been completed more than four years, calculated by the formula,*

$$\frac{27.5}{100}\mathrm{N}+\frac{14}{1000}\mathrm{T}+\frac{7}{1000}\mathrm{P}+500h.$$

| Name of Roads. | Year. | L'gth in miles. | G'de. in feet. | Miles run. | Thr'gh tonna'e | Thr'gh travel. | Actual expenses. | Calculat'd expenses. |
|---|---|---|---|---|---|---|---|---|
| Boston and Providence, | 1842 | 42 | 38 | 120,000 | 21,200 | 117,129 | $101,596 | $100,897 |
| Baltim'e and Washing'n, | 1841-2 | 30⅓ | | 91,428 | 27,369 | 114,260 | 73,684 | 76,166 |
| Petersburg Road, | 1842 | 61 | 30 | 131,160 | 22,000 | 16,000 | 96,398 | 92,489 |
| Nashua and Lowell, | 1841 | 14 | 10 | 44,040 | 28,663 | 85,737 | 30,708 | 33,131 |
| Baltimore and Ohio, | 1842 | 82 | 82½ | 299,617 | 44,477 | 34,380 | 220,135 | 192,925 |
| Portsmouth & Roanoke, | 1842 | 79 | | 96,000 | 5,975 | 7,662 | 73,345 | 76,703 |
| Boston and Lowell, | 1842 | 26 | 10 | 143,607 | 93,927 | 179,819 | 131,012 | 119,409 |
| Philadelp'a & Columbia, | 1842 | 82 | 45 | 261,844 | | | 116,000 | 112,979 |
| S. Carolina Road, | 1842 | 136 | 35 | 260,324 | 27,000 | 24,000 | 225,743 | 213,945 |
| Boston and Worcester, | 1842 | 44½ | 42 | 241,319 | 61,911 | 165,720 | 168,509 | 176,815 |
| Utica and Schenectady, | 1841-2 | 78 | | 152,764 | | 114,527 | 154,436 | 143,542 |

[NOTE.—The miles run on the *Petersburg Road* are assumed to be the same as in 1841; the tonnage is estimated from the tonnage of 1841, with an allowance for the increased receipts. The results on the *Baltimore and Ohio Road* for 1841 are preferred, because those of 1842 are complicated by the extension of the line to Cumberland. The report of the *Philadelphia and Columbia Road* contains only the expenses of motive power and repairs; the freight and passengers are conveyed by other parties; we have, therefore, in the formula to make $\mathrm{P}=0$ and $\mathrm{T}=0$, for this case. The tonnage and travel on the *South Carolina Road* are deduced from the printed reports. The actual charges on some of the lines will be seen to differ from other published statements; this will be found to arise from the fact that these statements contain charges for interest, ferries, cars, and motive power on branch roads, which are rejected in this comparison.]

Here is presented a list of eleven roads, situated in different sections of the country, and offering every variety of length, grade and business that could be desired, in order to put the formula to the severest test. The greatest difference which is exhibited in the whole list between the actual annual cost of maintenance, and the estimated cost, *is* 12 *per cent.;* certainly no closer agreement could be expected, since the actual expenditures fluctuate to that extent—and, perhaps, through wider limits—from year to year; the removals of decayed timber, and various contingencies, being found much more extensive some years than others. In looking over the list I am able to account, in almost every instance, for these departures from the formula, by my personal knowledge of the situation of the line. It will probably be seen on some future occasion, that those roads which now exhibit expenses above the formula, will fall below it for other years—a remark which is applicable to the Boston and Lowell, Baltimore and Ohio, and South Carolina Roads.

It is no part of my object to flatter the expectations of railroad companies, but to exhibit to them and the public the truth; to those companies whose works are now new, and who *seem* to be making money, I would suggest the timely formation of a contingent fund, to prepare them for a contingency which will as surely reach them as the next new year. It is bad policy to divide the *annual expenses* as if they were real profits; the money that is earned at the expense of the rails, cars, and machinery, should be hoarded to replace those things, and not distributed, as if they were to last forever. It can be shown that every company should annually store away, in times of prosperity, while their work is new, at least 6 cents for every mile travelled by their engines, 1 cent for every ton conveyed one mile, and 200 dollars for every mile of road, to replace decayed materials, and injured iron and machinery. If their profits will not permit that reservation, then the prudent man will avoid their stock; and the company should cut down their expenses to the limit assigned by the trade. Where these expenses do not consist of interest on debt, this retrenchment is almost always possible.

In the first of these tables the Reading Railroad appears to escape the application of the rule; the calculated expenses exceeding the actual charges, as stated by the company, some $14,000, or about 10 per cent. There has probably been a division made between the current and contingent expenses on this line; indeed, on inspecting the published exhibit, I find that the whole sum set down for *timber* used in repairing 94 miles of road, including rails, sills, &c., is just $2,431. Now, I know personally, that twice that sum would not pay for the timber required for repairing the bridges alone; the bridge account last year must have amounted to more than $12,000, and seems not to be included in the published statement. This sum being added to the published total, brings the year's expenses up to $151,000, or within 1¼ per ct. of the formula. Perhaps the company regard the loss of a bridge as so extraordinary an occurrence, that it can never take place again; but their report already points to another which is found to be "less permanent than the rest;" and time will show that no part of railway superstructures will long remain permanent under the action of heavy engines and their trains. Besides there will be freshets, and tornadoes, and fires; and on a road which has a great many bridges constructed of perishable materials, and which is travelled by 25 or 30 locomotives every day, or about 10,000 trains a year—with engines using pine wood for fuel—many accidents must be expected. One bridge per annum is a small allowance for the average loss; and if the bridges happen to be fortunate, there will be rotten sills, or crushed iron, enough to compensate for the difference.

We perceive then that the formula applies also to this road; and I will now insert a table exhibiting its application to all the roads of which I have been able to obtain the amount of trade, and annex a column showing the per centage of error for each; not having the number of miles run by passenger and freight engines separately in every instance, I make use of the mean value 27½ cents per mile run.

*TABLE.*

| Name of Road. | Year. | L'th. | G'ds. | Miles run. | Through tonnage. | Through travel. | Actual expenses. | Calculated expenses. | Err'r pr.ct. |
|---|---|---|---|---|---|---|---|---|---|
| Georgia Road, | 1842 | 147½ | 37 | 152,873 | 10,000 | 12,000 | $ 109,819 | $ 106,605 | —2¾ |
| Western Road, | 1842 | 156 | 83 | 397,295 | 40,000 | 53,000 | 256,619 | 256,187 | 0 |
| Syracuse and Utica, | 1842 | 53 |  | 84,000 |  | 70,769 | 62,325 | 62,315 | 0 |
| Baltimore and Susque'a., | 1842 | 70 | 84 | 128,349 | 23,000 | 16,500 | 75,224 | 74,379 | —1 |
| Reading Road, | 1841 | 56 | 19 | 83,717 | 24,000 | 31,453 | 62,635 | 61,318 | —2 |
| Reading Road, | 1842 | 94 | 35 | 198,055 | 65,000 | 33,720 | 151,000 | 152,911 | +1¼ |
| Boston and Providence, | 1842 | 42 | 38 | 120,000 | 21,200 | 117,129 | 101,596 | 100,902 | —⅗ |
| Baltim. and Washington, | 1841–2 | 30⅓ |  | 91,428 | 27,369 | 114,260 | 73,684 | 76,193 | +3½ |
| Petersburg Road, | 1842 | 61 | 30 | 131,160 | 22,000 | 16,000 | 96,398 | 92,310 | —4 |
| Nashua and Lowell, | 1842 | 14 | 10 | 44,040 | 28,663 | 85,737 | 30,708 | 33,131 | +8 |
| Baltimore and Ohio, | 1841 | 82 | 82½ | 299,617 | 44,477 | 34,380 | 220,135 | 192,925 | —12 |
| Portsmo'th and Roanoke, | 1842 | 79 |  | 96,000 | 5,975 | 7,662 | 73,345 | 76,703 | +5 |
| Boston and Lowell, | 1842 | 26 | 10 | 143,607 | 93,927 | 179,819 | 131,012 | 119,409 | —9 |
| South Carolina Road, | 1842 | 136 | 35 | 260,324 | 27,000 | 24,000 | 225,743 | 213,945 | —5 |
| Boston and Worcester, | 1842 | 44½ | 42 | 241,319 | 61,911 | 165,720 | 168,509 | 176,831 | +6 |
| Utica and Schenectady, | 1841–2 | 78 |  | 152,746 |  | 114,527 | 154,436 | 142,542 | —8 |
| Philada. and Columbia, | 1842 | 82 | 45 | 261,744 |  |  | 116,000 | 112,979 | —2¼ |
|  |  |  |  |  | Tons 1 mile. | Pas. 1 mile. |  |  |  |
| Aggregate, |  | 1251 |  | 2,886,292 | 33,360,560 | 57,726,906 | $ 2,109,188 | $ 2,068,165 |  |

One word more in reference to this table. I offer here a list of 17 railroads, presenting almost every conceivable variety of length, grade, and character. It is not a *selected* table, but contains the results of one year's operations on *every* road, without exception, concerning which I have been able to obtain the necessary data—materials which have only been procured by dint of great exertion. It will be seen that the management upon these various lines is very nearly uniform, and that they are *all* obedient to the *law*. The greatest departure from the formula is 12 per cent.

Now, this list embraces roads which are situated in every one of the sea-board States from Maine to Georgia; the aggregate length of line exhibited is 1251 miles; the engines traverse annually a space of 2,886,300 miles, and they carry no less than 33,360,560 tons, and 57,726,906 passengers one mile. The aggregate ordinary expense of maintaining this length of line, and accommodating this amount of tonnage, is actually $2,109,188 annually, and the calculated expense $2,068,165. The difference between the calculation and the fact is $41,023, or less than two per cent.

I conceive, therefore, that I have authority sufficient for announcing this formula as expressing the law of railroad expenses—a law to which all the roads in the country are obedient. If stronger evidence of its correctness could be offered, I know not in what it would consist. It is in vain to urge here that a certain road has peculiarly steep, or peculiarly light, grades, which should exempt it from the application of the rule. The formula which I announce, accounts for these differences. When the grades are easy, the engines make fewer miles, and the rule looks only to the miles.

There is yet another point of great importance connected with this subject, which ought not to be overlooked, viz., the "extraordinary expenses." It is the custom among too many of the parties interested in the railroads of this country, to look upon the suggestion that iron may be worn out, as a thing so chimerical and visionary, as to be entirely unworthy of their sober thoughts. In the course of a few years they are surprised by the fact—the certainty—that money must be raised, and that their iron *must be* renewed. Instead of being warned by experience, and commencing immediately the work of retrenchment, and the provision of a surplus fund to meet the recurrence of the contingency, they look upon it as extraordinary in the extreme—a sheer accident, which cannot occur again, or which can be warded off by a heavier iron. Experience and common sense teach that heavier iron will be attended with heavier expense; but they have *not yet* taught that the wear will be less. A heavier rail will longer resist a given trade; but will each dollar put into the heavy rail go farther? This, however, is a subject which must be reserved for a future number of the Journal.

To be Continued.

## Mechanics, Physics, and Chemistry.

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### *A notice of the occurrence of a Metallic Alloy in an unusual state of aggregation and molecular arrangement.* By Robert Mallet, Esq., M.R.I.A.

Amongst the several classes of substances which chemistry at present considers as simple, the metals stand pre-eminently marked by their almost invariable possession of a nearly fixed and striking group of sensible qualities, which together constitute the well known "metallic character." Some of these, such as lustre and fusibility, are common to every metallic body; but by the occasional variation of nearly every other sensible quality of the metals, the law of continuity remains unbroken, which unites them in different directions with the other classes of material bodies. Thus opacity, which is probably mechanically destroyed in gold leaf, is lost in selenium; and so, in this most prevalent of their properties, the metals, through tellurium, selenium, and sulphur, become translucent, and mingle with the nonmetallic elements. So also their solidity, at common temperature, is lost in mercury; their great density, in sodium and potassium; their malleability, in bismuth, antimony, and arsenic; while in tellurium, the power to conduct electricity is nearly wanting; and, lastly, hydrogen, to all intents a metal in its chemical relations, yet possesses not a single physical quality in common with these, but exists as an invisible and scarcely ponderable gas.

But although *different* metals thus vary in sensible qualities, those which collectively belong to the *same* individual metal are as remarkable for their permanence.

Unless selenium be admitted to be a metal, no approach to dimorphism has hitherto been recognized in any body of the class; the only case recorded, that by Dufresnoy, of the occurrence of cast-iron in cubes and rhomboids, not having been given by him with certainty, nor since verified by other observers. Hence, any instance of such a character, or tendency towards it, is worthy of attentive consideration; and it was with this view that the author brought before the Academy the following notice of the occurrence of an alloy of copper in two states, having totally different sensible and physical qualities, while identical in chemical constitution. The alloy in question, in its original, or normal, condition, was, in fact, a species of brass; and the particular specimen presented to the Academy, was a portion of one of the brass bearings, or beds, in which the principal shaft of a large steam engine revolved.

The bearing, or bed, of a shaft (as is generally known,) consists of a hollow cylinder, generally of brass, divided in two by a plane passing through the axis; its inner surface is finely polished, and sustains the shaft, during its revolution, which is also polished; the cavity of the brass being completely filled by the shaft, which, in the present instance, was of cast-iron, and about nine inches in diameter.

It frequently happens, notwithstanding the polish of both metallic surfaces, and the application of oil, that the friction due to their rapid passage over each other, while exposed to undue, or irregular, pressure, produces a considerable rise of temperature, and the brass becomes abraded. Its particles have no coherence, and much resemble the "bronze powder" used by painters.

In an instance, however, which some time since came under the author's notice, a different result took place. The minute particles of abraded brass, were, by the motion of the shaft, during a few hours, impacted into a cavity, at the junction of the two semi-cylinders of the bearing, where they became again a coherent mass, and when removed, presented all the external appearance of an ingot, or piece, of brass which had been poured in a state of fusion into the cavity. On more minute examination, however, the mass was found to differ much in its properties from the original brass, out of which it was formed.

The mass, or ingot, of brass, thus formed by the union of particles at a temperature which had never reached that of boiling water, and a fragment of which was presented, possessed on that side which had been in contact with the shaft, a bright polished metallic surface, like that of the original metal from which it had been formed: its other surfaces bore the impress of the cavity in which it was found. It was hard, coherent, and could be filed, or polished, like ordinary brass. It was, however, perfectly *brittle;* and when broken, the fracture, in place of possessing a sub-crystalline structure and metallic lustre, like that of the normal brass, or alloy, was nearly *black*, and of a fine grained *earthy* character, and *without any* trace of *metallic lustre*, or appearance.

Examined with a lens, some very minute pores, or cavities, are found throughout its substance, which is uniformly of a very dark brown, or nearly black, color, and devoid of all metallic character, except when cut, or filed—that is, in mineralogical language, its color is earthy black, and its streak metallic.

The author remarked that the observed cases of aggregation in solid particles, without the intervention either of a solvent, or of fusion, are extremely rare, and, as bearing upon the little understood subject of cohesive attraction, are of much interest.

The property of welding, which is possessed by all bodies, whether metallic, or not, which pass through an intermediate stage of softness, or pastyness, previous to fusion, and is not found in any substance which readily crystallizes, and hence passes *per saltum* from the solid to the liquid state by heat, forms a "frontier instance" of cohesive forces, being enabled to act in the aggregation of bodies, by only an approach to liquidity, or by a very small degree of intermobility.

Aggregation may also take place between portions of a body merely *softened* by a solvent, which is afterwards withdrawn, as in the familiar instance of India rubber, softened by naphtha for the manufacture of waterproof cloths; where the former, after being moulded, or united, in any way required, is left in its pristine condition by the evaporation of the naphtha from amongst its particles. But the cases of aggregation of solids, without such elevation of temperature, or the presence of solvents, are so rare, that but two or three have as yet been observed. Of these the most remarkable is that recorded by Pouillet, of the gradual, but complete, adhesion of surfaces of clean plate-glass, when left to repose on each other for a considerable time. It has also been stated, that clean plates of lead, or of tin, if pressed together by a considerable force when cold, require a proportionally great force to separate them. The case presented to the Academy, therefore, is another added to these rare instances of molecular aggregation in solids, independent of solution of fusion: the author, therefore, thought it worth while to examine, with a little care, the properties, both of the original brass, and of the mass thus curiously formed from it, or, as he thenceforth called them, of the *normal*, and the *anomalous* alloy.

The normal alloy is of a bright gold color, and sub-crystalline in structure, and of great toughness; its cohesive force is equal to 21.8 tons per square inch, which is above the average strength of any of the alloys of copper and zinc, or copper and tin, as found by my experiments on the cohesive power of these alloys, published in the proceedings of the Academy, and elsewhere. The cohesive force of the anomalous alloy is only 1.43 ton per square inch, or only about one-fifteenth that of the former.

The specific gravity of the normal alloy is = 8.600; that of the anomalous only = 7.581.

On submitting both alloys to analysis, their constitution proved identical; it is as follows:—

| | |
|---|---|
| Copper, - - - | 83.523 |
| Tin, - - - | 8.833 |
| Zinc, - - - | 7.510 |
| Lead, - - - | 0.024 |
| Loss, - - - | 0.110 |
| | 100.000 |

Uniting the small amount of lead with the tin, and dividing by the atomic weights, the nearest approach to atomic constitution is,

Copper, = 26.3 atoms.
Zinc, = 2.3 "
Tin = 1.5 "

These alloys have therefore not a strictly definite constitution, but one more nearly so than is usually found in commerce.

Both alloys are equally good conductors of electricity. The author examined their relative powers of conducting heat by the method which Despretz has employed with so much accuracy, and found that of the normal to that of the anomalous alloy as 36 : 35, numbers which are so nearly equal as to render it likely the difference is only error of experiment. He also endeavored to determine their relative specific heats, using the method of mixture, which was the only one which the small size of the metals permitted, and eliminating the errors incident to this mode, by first plunging the alloy hot into cold water, and then cold into hot water. In this way, if,

W and $t$ = the weight and temperature of the water,
M and $t'$ = the weight and temperature of the metalic alloy,
$m$ .... = the mean temperature of both,
S .... = the specific heat of the alloy,

there are two values, one where the metal is the hotter,

$$S = \frac{W(m-t)}{M(t'-m)};$$

and another where the water is the hotter body,

$$S = \frac{W(t-m)}{M(m-t')};$$

the mean of which is the specific heat of the alloy pretty exactly. The result gave the specific heat of the normal alloy = .0879, water as unity, and that of the anomalous alloy = .0848; both of which are below the specific heat assigned by Dalton to brass.

The normal alloy is malleable, flexible, ductile, and laminable. In the anomalous alloy there is an absolute negation of all these properties.

The normal alloy readily amalgamates with mercury at common temperatures; the anomalous alloy will not amalgamate with mercury even at 400° Fahrenheit.

When the anomalous alloy is heated to incipient redness in a glass tube, a minute trace of water, and of a burned organic substance probably adherent oil, are discoverable; it suffers no change, however, but a slight increase of density. The normal alloy suffers no change when so treated. The normal alloy, treated on charcoal with the blowpipe, fuses at once into a bead. On treating the anomalous alloy so, the fragment swells rapidly to more than twice its original bulk, on becoming bright red-hot; it then glows, or becomes spontaneously incandescent, in the way that hydrated oxide of chrome, and some others do, and instantly contracts to less than its original bulk, and becomes a fluid bead, which, on cooling, differs in no respect from the original alloy.

The anomalous alloy, when pulverized in an agate mortor, forms a *black powder*, devoid of all appearance of a metal; its filings also are quite *black;* while those of the normal alloy, produced by the same file, possess the usual metallic lustre. These facts, in connexion with the black color and fine earthy appearance of the fracture, bring to mind the case recorded by Sir David Brewster, of a piece of smoky quartz, the fracture of which was absolutely black, and yet was quite transparent to transmitted light, and whose blackness, he found, arose from the surfaces of fracture, consisting of a fine down of short and slender filaments of transparent and colorless quartz, the diameter of which was so small (not exceeding the one-third of the millionth part of an inch,) that they were incapable of reflecting a single ray of the strongest light. In describing this, Sir David Brewster predicted that "fractures of quartz, and other minerals, would yet be found which should exhibit a fine down of different colors, depending on their size."

It seems, therefore, extremely probable that the cause of the near approach to blackness in the fracture and filing of this alloy, arises from the excessive minuteness of its particles, and thus fulfils the foregoing prediction; the brownish tinge being produced by the reflexion of a little red light.*

The polish and power of reflecting light of the anomalous alloy, are not quite so great as those of the normal, but are still remarkable; and, as it seemed a matter of some interest to determine whether both reflected the same quantity, or intensity, of light at equal angles, the author endeavored to ascertain this point as respects heat, by means of Melloni's pile for the galvanometrical determination of temperature, assuming, as suggested to him by Professor MacCullagh, that what would be true of heat in this respect, would also be so of light; but from the small size of the reflecting surfaces he had at his command, he found it impossible to arrive at any trustworthy result. He is, however, inclined to believe, that both metals reflect most at a perpendicular incidence.

From the foregoing detail of the properties, in several respects so different, of this substance in its normal and anomalous states, the author thinks he is warranted in pronouncing it the first observed instance of an approach to dimorphism in a metallic alloy; and one, the mode of production and characteristics of which present several points of interest.

The conditions under which the alloy was aggregated, involved extremely minute division of the metal, great pressure in forcing the divided particles into contact, and nearly the exclusion of air. Considerable electrical disturbance may have also co-operated; such, together with induced magnetism, being the constant accompaniments of motion in heavy machinery. By re-establishing these conditions, under suitable arrangements, the author hopes to repeat the results thus accidentally first obtained, and so produce possibly dimorphous states of other metals, or their *definite* combinations.

There is but one body which occurred to the author presenting an analogy to this anomalous alloy, namely, indigo; whose fracture, it is well known, is fine earthy, and of the usual blue color, but becomes coppery, or assumes the metallic lustre on being rubbed, or burnished.

Lond. Edin. & Dub. Phil. Journ.

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## *On Palladium—its extraction, alloys, &c.* By William John Cock, Esq.†

This metal was discovered by Dr. Wollaston, in the year 1803,‡ as one of the alloys of native platinum, which, for some time after this discovery, appears to have been considered the only source of palladium; and as the quantity of the latter metal so alloying the native platinum is very small, it was then considered as a very rare metal: of late years, however, the importation into this country from Brazil of gold dust, alloyed with palladium, has occasioned a much more extensive supply of this metal, as it exists in some specimens of gold dust, to the extent of 5 or 6 per cent., and in one instance (that of the gold from the Candonga mine) it constitutes the only alloy of the gold.

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* Since this paper was read, Professor Lloyd suggested to the author, the analogy between the appearance of the powder and filings of the anomalous alloy and platina mohr, and those powders obtained by reduction of other metals by hydrogen. None of these, however, are coherent, which constitutes the peculiarity in the present case.

† Communicated by the Chemical Society; having been read January 3, 1843.

‡ Dr. Wollaston's original paper on Palladium, reprinted from the Philosophical Transactions, will be found in Phil. Mag. S. 1, vol. xx, p. 163; see also vol. xv, p. 287.—Ed.

The operation of refining is conducted in the following manner:—The gold dust is fused in charges of about 7 lbs. troy, with its own weight of silver, and a certain quantity of nitrate of potash; the effect of this fusion is to remove all earthy matter, and the greater part of the base metals contained in the gold dust, and in the silver melted with it. The fused mixture is cast into ingot moulds, and when cooled, the flux, or scoria, (containing the oxides of the base metals, and the earthy matter, combined with the potash of the nitre) is detached. Two of the bars thus obtained are then remelted in a plumbago crucible, with such an addition of silver as will afford an alloy containing one-fourth its weight of pure gold, and which being first well stirred to insure a complete mixture, is poured through a perforated iron ladle into cold water, and thus very finely granulated; it is then ready for the process of parting. For this purpose about 25 lbs. of the granulated alloy is placed in a porcelain jar, upon a heated sand-bath, and subjected to the action of about 25 lbs. of pure nitric acid, diluted with its own bulk of water; after the action of this quantity of acid, the parting of the gold is very nearly effected; but to remove the last portions of silver, &c., about 9 or 10 lbs. of strong nitric acid is boiled upon the gold for two hours. It is then completely refined, and after being washed with hot water, is dried and melted into bars containing 15 lbs. each.

The nitrous acid gas, and the vapor of nitric acid arising during the above process, are conducted by glass pipes (connected with the covers of the jars,) into a long stone ware pipe, one end of which slopes downwards into a receiver for the condensed acid, the other end being inserted into the flue for the purpose of carrying off the uncondensed gas.

The nitrate of silver and palladium obtained as above, is carefully decanted into large pans, containing a sufficient quantity of solution of common salt to effect the precipitation (as a chloride) of the whole of the silver, the palladium and copper remaining in solution in the mother liquor, which is drawn off, and when clear is run off, together with the subsequent washings from the chloride of silver, into wooden vessels, and the metallic contents are then separated in the form of a black powder, by precipitation with sheet zinc, assisted by sulphuric acid.

The chloride of silver, when washed clean, is reduced by the addition of granulated zinc, washed on the filter with boiling water, dried and melted in plumbago crucibles, without the addition of any flux.

From the black powder obtained as above, the palladium is extracted by resolution in nitric acid and super-saturation with ammonia, by which the oxides of palladium and copper are first precipitated, and then redissolved, while those of iron, lead, &c., remain insoluble. To the clear ammoniacal solution, muriatic acid is then added in excess, which occasions a copious precipitation of the yellow ammonio-chloride of palladium, from which, after sufficiently washing it with cold water and ignition, pure metallic palladium is obtained. The mother liquor and washings contain all the copper and some palladium, which are recovered by precipitation with iron.

Pure palladium is of a greyish-white color, rather darker than that of platinum; it is both malleable and ductile, though inferior in those qualities to pure platinum; its specific gravity is 11.3, which may be raised by hammering, or rolling, to 11.8. When perfectly pure it cannot be fused even in small quantities in ordinary blast furnaces, but may be brought into such a state of agglutination as to bear laminating, or drawing, into wire.

It may be completely fused by means of oxygen gas, and being kept some time fused, it is said to burn with the production of brilliant sparks; it is not tarnished by exposure to sulphuretted hydrogen, nor oxidated by the air at the ordinary temperature, or at a bright red heat; but it has the singular property of becoming oxidated by exposure to air at a dull red heat, the surface becoming colored in the same manner as iron or steel; and by continuing the process cautiously for some time, the metal becomes coated with a brittle crust of oxide of a brown color; this oxide is, however, reduced by a temperature very little higher than that necessary for its formation, and the surface of the metal regains its original color upon being heated to a bright red, and cooled out of contact with the air.

It is with difficulty soluble in nitric acid when pure and fused, or in a state of aggregation, but is readily so when alloyed to some extent with silver, or copper, and still more so when in the form of the black powder above referred to, in which state it is also soluble with the aid of heat in sulphuric and muriatic acids; but its proper solvent is nitro-muriatic acid, which, if it be not very much alloyed with silver, dissolves it readily.

It is, of all the metals, that which has the greatest affinity for cyanogen; and by means of cyanide of mercury, it may be separated from all its solutions.

It may be alloyed so as to be malleable with gold, silver, and copper; several of its alloys, with the two latter metals, being of great use in the arts from their hardness and elasticity, and non-liability to rust, or tarnish. When added to gold or copper, it whitens both those metals in a very great degree, about 20 per cent., being sufficient, in either case, to destroy the color of those metals.

The uses to which the alloys of palladium have been applied, are for the points of pencil-cases, for lancets for vaccination, for the graduated scales of instruments, as a substitute for gold in dental surgery, or for any purpose where strength and elasticity, or the property of not tarnishing, is required. Ibid.

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### *Account of a series of experiments on the comparative strength of solid and hollow Axles.* By John Oliver York, Assoc. Inst. C. E.

The author first describes the causes of fracture in railway axles, which he attributes to the sudden strains and injury produced by concussion and vibration. Those resulting from concussion are chiefly ascribed to a defective state of the permanent way, any sudden obstacle opposing itself to the progress of the train, and the severe shocks arising from the wheels coming in contact with the blocks and sleepers when thrown off the line. The force of vibration, and its certain effect to produce fracture in a body so rigid as a railway axle, is then fully explained; the evil arises from the impossibility of diverting from the axle the continued series of slight blows, or vibrations, to which it is subject, or of causing a free circulation of them through its entire length, since the naves of the wheels being fixed tightly on to the axles, form a point on either side for the vibrations to cease, and the particles of iron composing the axle at this point become dislocated by the continued and unequal strain, and ultimately break; the same action is described as taking place in the journal of the axle, and hence the fact that an axle seldom breaks excepting at the journal, or at the back of the nave of the wheel. The twisting strain to which railway axles are subject, is next considered, and a calculation entered into, to prove that upon a circle of only a few feet in diameter, and assuming a first-class carriage on four wheels to weigh 6 tons, the strain resulting from this cause is so slight, as to be unworthy of consideration in the inquiry. The paper next proceeds to point out, how and why the hollow axle is better able to resist the strains before referred to, than the solid ones now in use.

First, by the process of manufacture, by which the crystalization of the iron is avoided, and it is left in a better state for sustaining sudden strains and continued action. Secondly, by the position of the metal composing the axle, since the comparative strengths of axles are as the cubes of their diameters, and their comparative weights only as their squares,—consequently, with less weight, there must be increased strength: and thirdly, that the vibration has a free circulation through the length of the axle, no part being subject to an unequal shock from the vibration, and the axle would, therefore, receive much less injury from this cause. In conclusion, it is submitted that a railway axle should possess the greatest possible degree of rigidity between the wheels, to prevent it from bending, or breaking from concussion, combined with the greatest amount of elasticity and freedom in the particles of iron within the axle itself, to prevent the injurious effects of vibration.

The details of a numerous set of experiments are then given, to prove the superiority of the hollow axle in all these respects; the average of the whole of which is thus stated.

As regards rigidity to sustain a dead weight:—

The axles being supported at the ends, and the weights applied in the middle.

| Hollow Axles. | | | | | | Solid Axle. | | | |
|---|---|---|---|---|---|---|---|---|---|
| Weight. | | | | Deflect'n. | Perman't Set. | Weight. | | Deflect'n. | Perman't Set. |
| Tons. | Cwt. | Qrs. | Lbs. | Inch. | Inch. | Tons. | Cwt. | Inch. | Inch. |
| 7 | 14 | . . | 6 | $\frac{1}{16}$ | . . | 7 | 14 | $\frac{5}{16}$ | $\frac{1}{16}$ |
| 9 | 2 | . . | . . | $\frac{3}{16}$ | . . | 8 | 1 | $\frac{3}{8}$ | $\frac{5}{32}$ |
| 9 | 16 | . . | . . | $\frac{3}{8}$ | $\frac{1}{8}$ | | | | |

As regards its capability to resist a falling weight:—

5 cwt. 3 qrs. 6 lbs. falling from a height of 16 feet on to the centre of the axle.

| Hollow Axle. | | Solid Axle. | |
|---|---|---|---|
| 1st blow, deflection, | $1\frac{1}{3}$ | 1st blow, deflection, | $1\frac{3}{4}$ |
| 2nd " " | $2\frac{1}{4}$ | 2nd " " | $3\frac{1}{4}$ |
| 3rd " " | $3\frac{1}{4}$ | 3rd " " | $4\frac{1}{4}$ |

As regards the elasticity and fibrous quality of the journals:—

| Hollow Axle. | | Solid Axle. | |
|---|---|---|---|
| Number of blows to destroy journal (average), | 28 | Number of blows to destroy journal (average), | 10 |

Proportions of axles:—

| | Hollow Axles. | Solid Axles. |
|---|---|---|
| Diameter, | 4 inches. | $3\frac{1}{2}$ inches. |
| Weight, | 1 cwt. 2 qrs. 20 lbs. | 1 cwt. 3 qrs. 24 lbs. |

The paper is illustrated by specimens of the broken axles, both hollow and solid, and by diagrams of the mode of manufacturing the two kinds of axles.

Mr. Geach presented a series of specimens of ends broken off solid axles, made by the Patent Shaft and Axle Company, Wednesbury; they had borne severally 886, 148, 293, and 278 blows of a sledge-hammer, weighing 38 lbs., before they separated from the body:—above twenty more ends had been broken off, the weakest requiring 138 blows. The diameter of these journals was $2\frac{1}{2}$ inches.

An axle was exhibited which had been bent nearly double under an hydraulic press, with a pressure of 64 tons: the journals ($2\frac{1}{2}$ inches diameter) were also bent in opposite directions, by repeated blows of a sledge-hammer, without any signs of fracture being perceptible.

The firm, which Mr. Geach represented, had made upwards of twenty-five thousand axles, and had tried a very large number by breaking them; they almost uniformly found them of good quality, which might be attributed to the mode of manufacture. Around a centre bar of iron were placed eight bars, rolled to a proper form, to complete a circle, the joints radiating from the centre; they were then welded together by rolling, and finished under the hammer; the fibre of the iron, it was contended, was thus worked, and remained in its most favorable position.

He was not opposed to the principle of hollow axles, but he wished to prevent any unnecessary prejudice against solid ones, by inferences from any one set of experiments; he would, therefore, suggest that another series of experiments should be made between the relative strength of the two kinds of axles, for which he would contribute the necessary number of solid ones.

Mr. York described the manner in which the solid axles had been selected for the purpose of experiment. Having obtained General Pasley's consent to be present on the occasion, he ordered axles from the Patent Axle Company, and another eminent maker, and selected also several other axles supplied by the Patent Axle Company to the London and Birmingham Railway; these axles were new, never having been under any carriage; he contended that the result of the experiments afforded a fair specimen of the axles generally in use, and were such as the public were in the habit of riding upon. The axles which had since been made by the Axle Company, and were then exhibited to the meeting, showed a quality of iron that could not be surpassed: if this was the usual quality made use of by that company, it still more forcibly proved his position as to the uncertainty of manufacturing solid axles, for while one specimen took a great number of blows to break it, the majority of them were fractured by a slight force; it was this uncertainty which he proposed to avoid, and he contended that it was inseparable from the method of making axles described by Mr. Geach; for, in passing the faggot through the rolls to weld the bars together, it frequently happened that they were only united to a depth of one-half, or three-quarters, of an inch; hence, it was, to a certain extent, hollow, and partially avoided the injurious effect of hammering; if, on the contrary, they were perfectly welded, the iron became crystalized, as in any other solid axle: this fact was proved by the specimens before the meeting, those that were solid having been broken by a very little force, and the unsound ones requiring a great number of blows to produce fracture.

In the experiments, the hollow axles had broken under a different number of blows, but this was owing to their having been made of larger diameter in the journals, than the solid ones, (but with only an equal quantity of metal in them,) and afterwards turned down to the same diameter, which left them of unequal thickness, and too thin for a fair test; still, however, with less metal than in the solid ones, they were stronger; this might be accounted for by the mode of manufacture, as by retaining the axle hollow, the crystalization of the iron was avoided.

The present mode of making the hollow axles, he described to be by taking two trough-shaped semi-circular pieces of iron, bringing their edges together, and welding them under a hammer between swages. He, however, dissented from the process of hammering, and intended to finish his hollow axles by compression only. This, he contended, would avoid the injury done to the iron by the present mode of manufacture, and that with the same quantity of iron, the strength of axles being as the cubes of their diameters, and their weights only as the squares, a hollow axle must possess considerable advantage over a solid one.

Hollow axles had long been considered desirable, but the expense of making them had hitherto prevented their use; he had reduced their cost, by his process, to the same rate as the solid ones, and felt confident that in bringing them under the consideration of the profession, through the Institution, they would be faily treated, and ultimately adopted.

General Pasley confirmed the correctness of the results recorded by Mr. York, and the satisfactory nature of the experiments which had impressed him with a favorable opinion towards hollow axles. It was of importance to avoid deflection, as it was almost as fatal as fracture in causing accidents. After the late accident on the North Midland Railway, he observed a solid axle bent into the form of the letter C, and the upper portions of the periphery of the wheels nearly touching each other. The hollow axles would certainly resist deflection better than solid ones of corresponding weight.

In answer to a question, Mr. York said that the iron was chiefly injured by the amount of hammering which it received in forging.

Mr. Taylor remarked, that the question of the amount of injury received by iron in working, was discussed at the meeting of the British Association in 1842, and the effects of vibration and electricity had also been treated of by foreign engineers. It appeared to be generally admitted, that the great source of mischief was the cold swageing, which the iron received, in order to give the work a good appearance. In order to test this, Mr. Nasmyth subjected two pieces of cable bolt iron to 160 blows between swages, and afterwards annealed one of the pieces for a few hours. The unannealed piece broke with five or six blows of a hammer, showing a crystalized fracture; while the annealed piece was bent double under a great number of blows, and exhibited a fine fibrous texture. The fact of the fibre being restored by annealing was well understood and practiced by smiths, particularly in chain-making.

Mr. York could not entirely subscribe to the great benefit of annealing, as he had found that after annealing one end of a hollow axle for forty-eight hours, it was broken off by 32 blows, while the other (unannealed) end of the same axle resisted as far as 78 blows.

In answer to a question from Alderman Thompson, Mr. York said, that he had found as much mischief arise from over-heating iron, as from over-hammering it; but the difference of the appearance of the fracture, indicated immediately when iron had been burned.

Mr. Taylor said that in Mr. Nasmyth's experiments, the over-heated iron was almost as fragile as glass.

Mr. Gravatt believed that vibration, whether caused by the smith in working the iron, or by the use to which the bar was appropriated, was the reason of its fracture, and it was certain that a constant change was going on in all manufactured iron. At the Thames Tunnel, the "fleeting bars," used as levers for turning the large screws for forcing forward the shield, never lasted longer than three or four weeks, although they were very strong, and were made from the best materials by careful smiths. They were only used occasionally, and then without any concussion, having only the power of eight men exerted upon them: yet they broke constantly, and the fracture exhibited a bright crystalized appearance. It was found at last, that in order to give them duration, they should be left rough, and not hammered much in working.

Mr. Newton observed, that full ten years since, Dr. Church had used hollow axles for his experimental steam coach on common roads, being convinced of their superiority.

Mr. Fox was an advocate for the hollow axles, but he did not consider the present experiments quite conclusive, as there were differences in the relative dimensions of the axles experimented upon; he would suggest another series of trials, upon a larger number of axles, as the subject was one of great importance, not only to manufacturers, but to the public, whose safety in travelling depended upon the goodness of the axles under the carriages. He had used upwards of 5000 axles made by the Patent Axle Company, and had made many experiments by breaking them; the average result was equal to that quoted by Mr. York. He agreed in the danger arising from overheating iron, as also from over-hammering it, and for some time past he had caused all the axles to be made 6 inches longer than was necessary, in order to cut 3 inches off each end, to try the quality and the appearance of the fracture of the iron.

The President remarked, that there could not exist a doubt as to the greater strength of a hollow axle, as compared with a solid one; both containing the same weight of material; the principal question to be considered was that of vibration, and its effect upon the cohesive strength of the metal, whether the action upon the particles was more irregular in the solid body, and more distributed in the hollow one; he recommended this investigation to some of the mathematicians who were present; the result of their inquiries might materially aid in the development of truth from the practical experiments.—[*Trans. Inst. Civil Eng.*] Lond. Journ. Arts & Scien.

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## *Flying Machines.* By John Bishop.

We are not destitute of data for estimating the force which is called into action in order to sustain, and keep in motion in the air, bodies, more or less heavy; sufficient has, at least, been done to enable us to form some conjecture respecting the probability of the success of Mr. Henson's machine. An elaborate memoir, on this subject, by M. Chabrier, has been published by the Institute of France, in which will be found a profound mathematical inquiry into the conditions necessary for the movement of machines in the air. In Dr. Todd's Cyclopædia of Anatomy and Physiology, part 23, article *Motion*, I have contributed a number of illustrations, by ascertaining the weight of various insects, bats, and birds, and the amount of surface in each respectively. I have also computed the number of strokes made in a second by the wings of the rook and the pigeon during flight. It appears that the average weight of the pigeon is 4347.344 grains; that of the rook 4170.25 grains; and that of the canary 229 grains; whilst the areas of their wings are respectively 0.6198, 1.11, and 0.054 of a square foot. Hence, we see that the areas of the wings of birds do not vary as their weight; and that the rook has nearly half a pound weight to the square foot, and the pigeon one pound; the former making two, the latter three, effective strokes of the wings in a second. The weight of the former is, therefore, greater, that of the latter less, in proportion to the surface presented to the wind, than in Mr. Henson's machine.

It must, however, be borne in mind, that in this machine the surface presented to the wind has no motion like the wings of birds, neither does the machine possess the power of ascending vertically. In birds, on the contrary, according to Borelli,* the power of the muscles which move the wings, compared with their weight, is more than 10,000 to 1; whilst their mass, compared with the muscles moving the legs, is as 3 to 1. We agree with M. Chabrier, that the amount of force requisite for ærial progression is so enormous, owing to the rarity of the atmosphere, that it would be impossible for a man to sustain himself in the air by his muscular strength alone, in any manner, in which he is capable of applying it. For example, it is calculated that a man can raise 13.25 lbs. avoirdupois, to a height of 3.25 feet in a second, and that he can continue this exertion for eight hours in a day. In that space of time he will, therefore, exert a force capable of raising 381,600 lbs. to a height of 3.25 feet, or 45,700 lbs. to a height of 26 feet, which, according to M. Chabrier, is the height to which the swallow would raise itself in a second of time, by the force which it is obliged to exert in order to sustain itself in the air. Now, if we suppose the conditions, necessary for flight in man, to be the same as in birds, and that a man whose weight is 150 lbs., could concentrate the muscular power of a day's labor into as short a period as the accomplishment of the object required, the time, $t$, during which he would be enabled to support himself in the air would be,

$$150\,t = 47{,}700;$$

hence, $t = \frac{47700}{150} = 318''$, or about five minutes.

The surface of the wings in the rook and the pigeon when expanded, will not support them stationary in the air, unless they move with rapidity; for when the wings of the rook are expanded motionless in the air, the bird descends by its own gravity with considerable velocity; and as it has a greater surface, compared to its weight, than Mr. Henson's machine, it follows that the latter would be precipitated to the earth with still greater velocity, should the propelling apparatus get out of order in its transit through the air.

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* De Motu Animalium.

It appears by M. Chabrier's analysis, that the quantity of force expended to keep a body, whose weight is W, stationary in the air, (all other conditions being supposed the same,) is as $\sqrt{W^3}$ directly, and $\sqrt{\text{density of the air}}$, inversely. I have, however, elsewhere shown that the quantity of force employed for this purpose, by some birds, is rather less than that here stated.

Lond. Mech. Mag.

## *Description of Lieutenant D. Rankine's Spring Contractor.* By Wm. John Macquorn Rankine, Assoc. Inst. C. E.

This paper describes a contrivance for suiting the action of the springs of railway carriages to variable loads, so as to give the proper ease of motion to a carriage when heavily laden, and at the same time to be sufficiently flexible for light loads. Its effect is to make the strength and stiffness of the spring increase in proportion to the load placed upon it. Each extremity of the spring, instead of supporting a shackle, or roller, as in the usual construction, carries a small convex plate of cast-iron. The form and position of this plate are so adjusted, that when the carriage is unloaded, it bears on the extreme end of the spring, thus allowing it to exert the greatest amount of flexibility; but as the plate is convex, the more the load increases, and the further the ends of the spring descend, the nearer does the point of bearing of the plate upon the spring approach to the centre, or fulcrum, so that the convex plate, or contractor, tends to diminish the virtual length of the spring in proportion to the load, the result of which is to increase the strength of the spring in the inverse ratio of its virtual length, and its stiffness in the inverse ratio of the cube of the same quantity.

The author then gives in a tabular form, the details and the results of some experiments made on springs of this description, which are similar to those now in use on the Edinburgh and Dalkeith Railway. The springs were 4 feet long, each consisting of ten plates, each $\frac{1}{2}$ inch thick, and $2\frac{3}{4}$ inches broad. The contractors were cast with a radius of $12\frac{1}{4}$ inches, and so constructed as not to act until the load on each spring exceeded 10 cwt., and with a load of 30 cwt., they should have contracted the distance between the bearing points to 3 feet 4 inches, instead of four feet; by this means the strength of the spring was increased in the ratio of 6 to 5, and its stiffness in the ratio of 216 to 125.*

The advantages stated to be derived from the use of these springs on the Edinburgh and Dalkeith Railway, and other lines, are—That they afford the same ease of motion to a single passenger, as to forty or fifty in one carriage; they save wear, both of carriages and railway track; they produce the strength and stiffness requisite for the maximum load with less weight of metal; they are not more expensive than rollers; and they are not offensive in appearance, indeed, they would not be observed unless they were pointed out.

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* Since this communication was made, contractors of great length, and increased radius of curvature, have been applied, so as to produce a contraction of 6 inches at each end of the spring when fully loaded, which increases the strength in the ratio of 4 : 3, and the stiffness in that of 64 : 27. The details of the construction of these contractors, with a drawing of them, as applied to the springs of the carriages on the Edinburgh and Dalkeith Railway, are given in the addendum to the original paper.

Ibid.

## *On an application of the Electrotype Process, in conducting Organic Analysis.* By Robert Mallet, Ph. D.

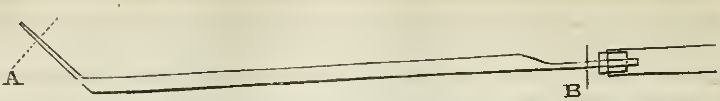
An application of the electrotype process has been made by me. which appears of some value to those engaged in the pursuit of organic analysis; I therefore hope a brief notice of it may not be out of place in the Philosophical Magazine. When very high temperatures are required to effect, or complete, difficult combustions with oxide of copper, or chromate of lead, as in the determination of carbon in certain varieties of cast-iron (which indeed suggested the application to me,) the glass tube is liable to soften and get distorted. though of Bohemia glass, and it has been usual to cover it by lapping a spiral strip of thin copper round the tube. This, however, is never in close contact, even when cold, and the tube is liable to be broken either in the lapping, or during the combustion.

The method I have now to mention as a substitute for this, consists in brushing over the outside of the combustion tube with a very thin coat of Canada balsam and turpentine, dusting it over with fine powder of plumbago which adheres thereto, connecting one end of the combustion tube with a copper wire, and plunging the whole into a cell of sulphate of copper, in the common electrotype arrangement. In a few hours the whole exterior of the tube is found covered with a perfect, close, and coherent jacket, or tube of copper, and may now be at once put into use.

The copper covering adheres so close to the glass tube, and is so completely itself an *air-tight* combustion tube of copper, that should the glass tube crack in the combustion, it is of little importance.

The film of Canada balsam between is so indefinitely thin, that its decomposition has no injurious effect. A combustion tube of 18 inches long is only increased in weight about $\frac{1}{10}$th of a grain by this coating, when dry (without the plumbago of course.) For the latter, Dutch gold-leaf may be substituted with advantage.

The glass combustion tube is best filled with the oxide of copper, &c., and subject of analysis, before the precipitation of the copper upon it, and the tube is best drawn out to a neck at the end next the kali apparatus, as well as at the remote one, the former being done immediately after the filling; the latter neck is opened on commencing the combustion, and the union with the train of absorbent vessels is made by cork in the usual way, but in inverse order, that is, the first cork is not inserted *into* the combustion tube, but placed *upon* the drawn-out neck, thus—



The whole tube from A to B, being covered with copper, the passage for the gases is insured by a sharp blow or two on a table of the combustion tube as usual.

In the methods proposed by Professor Bunsen, of Marburg, some time ago, chiefly for the determination of nitrogen by combustion in a hermetically sealed tube, he imbedded the combustion tube in a mould of plaster of Paris, to prevent the elastic gases evolved from bursting the tube. The process was difficult and uncertain, but the application of the method above described, gives as much facility to the performance of organic analysis by this method, as by any other.

This mode of precipitating copper upon glass, is also susceptible of many other useful applications, in the arrangement of chemical apparatus, when heat, or pressure, is concerned.

Lond. Edin. & Dub. Philo. Mag.

## *On a method of Etching on Hardened Steel Plates, and other Polished Metallic Surfaces, by means of Electricity.* By J. H. Pring, M. D.

I herewith transmit to you a rough specimen of what I conceive to be a novel employment of the power of electricity, and shall be gratified, should the process by which it was effected, prove susceptible of any useful application to the arts.

The method which I employed in the production of the characters on the accompanying plate,* was the following:—Having six batteries of the kind invented by Mr. Smee, the platinized silver plate of each being about three inches square, I attached the steel plate to be etched upon, to the zinc extremity of the batteries, a coil of covered wire, of considerable length, being previously interposed between the steel plate and the zinc: then taking the wire connected with the platinized silver in my hand, I used it as an etching-tool on the steel plate—an electrical spark of great brilliancy, accompanied by a slight indentation on the steel, was the result of each contact of the wire with the plate.

The wire by which the etching was made was of platina; the part at which it was held, was carried through a glass tube for the purposes of affording a more convenient handle, and of protecting the hand from shocks to which it might otherwise have been exposed.

By using the wire connected with the zinc of the batteries as the etching-tool, and attaching the steel plate to the platinized silver, a very different effect is produced. With the apparatus thus arranged, the spark that results from the contact of the wire with the steel plate, is accompanied by a deposition of a minute portion of the substance of the wire on the steel; by using different wires, therefore, as of gold, silver, platina, &c., a variety of ornamental designs may probably be formed on polished steel surfaces.

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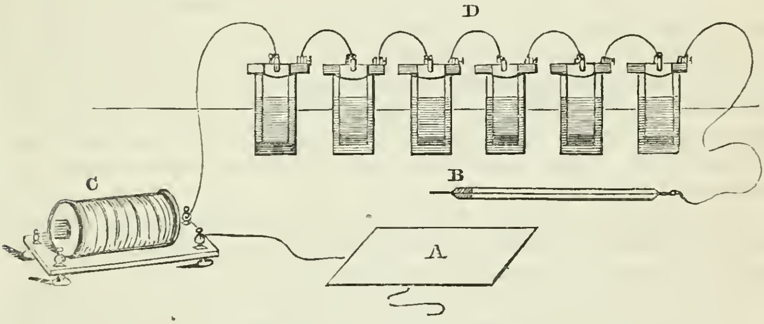
* This was a steel plate, on which the words "Etched by means of Electricity. Bath, 30th June, 1843. J. H. P." together with some ornamental devices, had been produced by the above method. It gave only a faint, just legible impression, by the copper-plate press.—Editor.

The effect of the electrical agency here described, is not, however, confined to steel; a somewhat similar one may be obtained by substituting plates of other metals. By augmenting the quantity and intensity of the electrical current, it seems probable that the effect on the steel, or other metals, would be proportionally increased; and it may be anticipated that, by other modifications of the process, its applications may be advantageously extended.

The accompanying sketch, in which the apparatus is represented lying ready for use, may, perhaps, serve to illustrate the foregoing description.



A, the steel, or other metallic, plate to be etched upon.
B, the etching point of platina wire projecting from the glass handle.
C, the coil of covered wire.
D, the batteries.

Ibid.

### *On some Experiments made by a Commission of the Royal Institute of the Pays Bas, with a view of verifying the property ascribed to Oil, of calming the waves of the Sea.*

The Annales de Chimie et de Physique, for the month of March, 1842, contain a Memoir, by M. A. Van Beek, on the property possessed by oils of calming waves, and rendering the surface of the water perfectly transparent. After citing many testimonies to prove the existence of this property, and its efficacy, the author goes on to express the opinion that we may find, by the use of oil during tempests, a means of protecting piers, and other marine constructions, against the violence of the waves, by pouring it on the water not far from the sides.

So bold and singular a supposition could not fail to attract the attention of men of science; accordingly, the Academy of Sciences of Paris appointed a commission to examine the subject. But, on this occasion, it will be neither useless, nor uninteresting, to our readers, to know that the same question has already been agitated in Holland.

M. Van Beek, who is a member of the Royal Institute of the Pays Bas, made a proposal last year at the sitting of the class of sciences, having for its object to prevail on the government to institute experiments with the view of proving that oil had the power of preserving piers against the violence of the sea.

This proposition was not generally approved of. Three members were chosen to examine further into its importance; but these three persons in their turn being by no means unanimous in the considerations and advice which they offered, it was thought that the best way of getting rid of the embarrassment, was to adjourn the consideration of the proposal, and endeavor, before resuming it, to obtain some positive light on the question itself. In consequence, a commission of five members was appointed, with instructions to make direct experiments on the power oil exercises on the waves near the coast; and it is the report of this commission which we are now about to communicate.

The commission nominated from among the members of the first class of the Royal Institute of the Pays Bas, and directed to make experiments on the power attributed to oil, and other fat substances, of diminishing the violence of waves, report what was done and observed by them on this subject.

The commission having chosen the village of Zandvoort, situate on the shore of the North Sea, as the place for making their experiments, agreed to meet there on the first stormy day.

They were obliged, however, to change their intention, and to fix on a certain day, on account of the period of the season (the month of June,) during which tempests are rare; and the blasts of wind of any degree of strength being also of short duration, it would have been impossible for them to have met at the village mentioned in proper time. They came more readily to a decision by considering that, if oil really exercises on the water, in a state of great agitation, the power supposed, it must be still more easy to recognize this property on a sea put in motion by a wind of moderate force. Meanwhile, two of the commissioners, happening to be in the country on a day when the wind was blowing violently, made a trial by pouring a small quantity of oil on the water of a rivulet, and observed an evident change in the appearance and movement of the water.

Another member of the commission made, on the same day, a similar trial on the Spaarne, (a small river near Hærlem,) and obtained the same result.

Encouraged by all these observations, the 28th of June was fixed on for the purpose of proceeding to ulterior experiments.

The commissioners assembled at Zandvoort on the day mentioned, at nine o'clock in the morning. Some of them proceeded a short distance from the shore, in order to pour the oil upon the water, and observe the results; the others remaining on land, and not knowing either at what moment, or how many times, the oil was poured out, were to keep their eyes fixed on the waves, which rolled from the boat towards the shore; by these means, their opinion, exempt from all influence, might be considered as so much the more impartial.

The wind was south-west, and of moderate force; the quantity of oil poured out at four different times, namely, at 43, 45, 50, and 54 minutes past nine o'clock, amounted to 15 litres (upwards of 3 imperial gallons); the tide was flowing, and would not reach its full height till 21 minutes past eleven o'clock.

The commissioners who remained on the shore, not having remarked any effect which could be ascribed to the effusion of the oil, and the same thing being the case with those engaged in pouring it, we might already consider the question, if oil poured at a little distance from our piers could protect them from the fury of the waves, as answered in the negative. Nevertheless, the commissioners thought it incumbent upon them to make a second trial at a somewhat greater distance from the shore. Two of them were rowed beyond the rocks, and then cast anchor.

The distance was calculated by the boatmen at 300 yards; the sounding line indicated a depth of about three yards; and the waves were rolling considerably. More than the half of 15 litres of oil was poured out in the space of five minutes (from 15 to 10 minutes before 12 o'clock,) and the commissioners did not observe the slightest effect in relation to the object of their mission. They saw the oil swimming on the surface of the water, partly united in spots of an irregular form, partly extended, and forming a pellicle, and partly mingling with the foam of the waves, and sharing in their oscillatory movements.

When returning to the shore, at the moment of passing the rocks, the commissioners caused the rest of the oil to be poured on the water, and they can testify that it had no effect in diminishing the motion of the waves, for they were many times abundantly sprinkled with the spray. It is unnecessary to add, that those who remained on land, had remarked nothing at all which could be attributed to the effusion of the oil.

After all that has been said and written on this subject, the commissioners are astonished at the negative result of their experiments, and, limiting themselves to the account of them, they add no observations. They believe themselves, however, authorized to assert, as their personal opinion, that the idea of protecting our piers by means of oil, is not a happy one.*

Edin. New Phil. Journn.

## *Tides at Otaheite.*

That it is invariably high water at noon, at the island of Otaheite, has been a received fact ever since the days of Cook; but it now appears, from a tide journal kept at the harbor of Papeete, by Mr. Richardson, R. N., and communicated to the Royal Society by Capt. Sir Edward Belchor, that this is not correct—though, certainly, the cause of the tides at this island do present some anomalies very difficult to account for. "By a reference," says Sir Edward, "to the tide registry annexed, it will be found that there are two distinct periods of high water, during each interval of twenty-four hours; and that during the seven days preceding, and seven days following, the full and change, they are confined between the limits of 10 A. M., and 2h. 30m. P. M., the whole range of interval, by day, as well as by night, being about 4h. 27m. Commencing with the seventh day preceding the full moon, viz., the 9th of April, it will be perceived that high water occurs at 10 A. M., this being the greatest A. M. interval from noon; and that on the 16th, at the full moon, it occurs nearly at noon. Passing on to the 23rd, it reaches the greatest P. M. limit at 2h. 30m., and on the second of May it again reaches the noon period. Between the 23rd and 24th, however, a sudden anomaly presents itself; throughout the day of the 23, the variation of the level does not exceed 2½ inches, and the general motion is observed to be 'irregular.' The time of high water is also the extreme P. M. limit. On the 24th we discover that it has suddenly resumed *the most distant* A. M, *period,* viz., 10 A. M., but proceeds regularly to the noon period at the change. Although the differences of level do not, at full and change, exceed 1 foot 4½ inches, still, I presume, that we have sufficient data to establish the fact, that it is *not invariably high water at noon* (as asserted by Kotzebue, Beechey, and others:) and, further, that we have corresponding *nightly periods* of high water. It is evident that the time of high water at full and change may be assumed as that of noon, because we have sufficiently decided changes of level to fix the approximate period of high water. It does not appear by these registers, that any higher levels result from the rollers sent in by the strong sea breezes, (as asserted by several writers,) but rather the contrary, the highest levels being indicated during the night, when the land breezes prevailed."

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* From Annales de Chimie et Physique. T. vii. p. 371.—The experiments appear to have been conducted on too small a scale to afford satisfactory results.—EDITOR.

Lond. Mech. Mag.

## GLEANINGS FROM FOREIGN JOURNALS.—No. 1.

*New mode of measuring the depth of the Sea.*—M. Aimé describes an apparatus for sounding, in which a weight attached to the line, may, on reaching the bottom be detached, so that the line is drawn up with very slight resistance. He has affixed to this apparatus a vessel for collecting water at different depths, and made, at Algiers, a series of experiments at various distances from the surface, from about 350 to 2200 yards, from which he infers that the amount of gas absorbed by the water, at different depths, is nearly the same, and that the saline constituents are likewise uniform in quantity.

Ann. de Chim. et de Phys.

*On Galvanic Induction.*—M. Abria, Professor in the Faculty of Sciences, of Bordeaux, has repeated and varied the experiments of

Professor Henry, of Princeton,* on the inductive action of a galvanic current, confirming the laws already deduced. Ibid.

*Resistance of Earth to the motion of Electricity.*—Prof. Jacobi concludes, from his experiments, (Bulletin of the Petersburg Academy, vol. i.) that the resistance of earth, the surface of the ground, to the motion of galvanic electricity, may be considered as nothing, and hence that it may be used to form part of a circuit in telegraphing.
Poggendorf's Ann. March, 1843.

*Another new Metal.*—Mosander has discovered a new metal associated with cerium, lanthanun, and didymium, in Gadolinite.
Chem. Gaz. Aug. 1843.

*Elasticity, &c. of Alloys.*—The experiments of M. G. Wertheim show that, 1. In alloys of metals the less the distance of the molecules, the greater the elasticity of the alloy. 2. The coefficient of elasticity of alloys generally, may be calculated from the coefficients of the components. Certain alloys of zinc and copper are exceptions to this rule. 3. The tenacity, limit of elasticity, and tensile power of alloys, cannot be determined from similar particulars in regard to their constituents. 4. Alloys resemble pure metals, in reference to their transverse and longitudinal vibrations, and to tensile power.
Compte Rendu of Acad. Sc. of Paris, May, 1843.

*Action of Water on Bodies.*—When water dissolves, cold is produced, this is shown by Peltier, by the action on the galvanometer through a thermo-electric current; when water combines, chemically with a body, heat is produced. When water is exposed to electrolization, hydrogen is condensed about the negative electrode, and oxygen near the positive, and if the ends of the wires of a galvanometer be plunged into any part of the fluid, except the middle, a current will be developed from the unequal distribution of the gases.
Peltier in Compte Rendu, &c.

*Heat from Comets.*—M. Ad. Mathiessen found sensible heat from the zodiacal light, by the aid of Melloni's thermo-electric arrangements. He could detect none in the light from the tail of the great comet of 1843. Ibid.

*Speaking Machine.*—A machine capable of emitting sounds resembling the human voice, has been exhibited lately at Berlin. The inventor is from Vienna, and named Taber. The sounds of the different letters may be produced separately, or in combination. The voice is also susceptible of modulation.
Poggendorf's Ann. Feb. 1843.

*Thermo-electric from Hydro-electric currents.*—Poggendorf gives a simple way of proving that a galvanic current passing through the junctions of dissimilar metals, produces a thermo-electric current in the same direction, and with the same electro motive force as its own. One pole of a thermo-electric battery is connected with one pole of a galvanic battery, and with a galvanometer; a wire from the other pole of the thermo-battery is made to touch alternately, for an instant, the other pole of the galvanic battery and the galvanometer, so that the force which acts upon the galvanometer needle, is alternately that of the hydro-electric current, and of the thermo-electric current produced by it. The needle of the galvanometer continues its motion, and reaches the same point that the hydro-electric current would have carried it to, had it acted the whole time. Ibid.

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* Amer. Philos. Soc. Trans. Vol. viii.

Professor Knorr, of Kasan, in his experiments on the cause of the images produced on metallic plates by coins and similar articles, found the following significant result. When the temperature of the air was between –8 and –19° Fahrenheit, an engraved copper plate was placed upon a polished plate, and left there from six to twenty hours. The vapor of iodine brought out no picture on the polished surface, while breathing on similar plates which had been in contact at a temperature of 66° Fahrenheit, sufficed to show an image.

Poggendorf's Ann. April, 1843.

*Amalgam of Sodium in a Galvanic Pair.*—F. C. Henrici substituted an amalgam of sodium for zinc in a galvanic pair on a Daniell's constant battery. The amalgam readily adhered to a brass wire so that the exchange for a zinc cylinder was easy. When a very small mixture of sulphuric acid and water was used as the exciting liquid about the zinc, or amalgam, cylinder, the following results were obtained. In ten minutes with the zinc cylinder, 7 parts of gas were collected in a voltameter, with the amalgam cylinder 92. In twenty-three minutes, 265 with the amalgam cylinder; in forty-five minutes, 34 with the zinc. In 208 minutes the decomposition, when the zinc cylinder was used, amounted to 237 parts, or less than the result in twenty-three minutes with the amalgam cylinder. With a saturated solution of common salt, instead of the dilute acid, the results were in five, ten, and fifteen and one-third minutes, when the amalgam cylinder was used, 115, 190, and 265 parts, and in five and ten minutes, respectively, with the zinc cylinder, 38 and 62 parts. With a stronger mixture of sulphuric acid and water, the amalgam cylinder gave 30 parts in one minute, and the zinc 51½ in ten minutes.

Ibid. Feb. 1843.

*Jupiter's Moons.*—A Japanese Encyclopædia published prior to A. D. 1713, gives, according to Libri, a figure of the disk of the planet Jupiter, accompanied by two small stars, and the text states that they appear to be connected with (as it were dependants on) the planet.

Ibid.

*Level of the Caspian.*—M. Hommaire Dehel finds, by leveling along the streams emptying into the Sea of Azof, on one side, and into the Caspian, on the other, that the Caspian is 18,301 metres (about 20,000 yards) below the Sea of Azof. He denies that the Caspian is the centre of a depression sui generis, but concludes that it occupies the lower part of a basin which the sea once filled.

Compte Rendu of Acad. Sc. of Paris, 1843.

*Images on Resin.*—When an electric discharge is passed through a coin placed upon a cake of resin, the base of which communicates with the ground, the part of the cake impressed separates minium from a powder of sulphur and minium rubbed together, and thrown in dust upon the surface. (Masson.) Ibid.

*Images on Glass.*—M. Karsten states that if an electric discharge be passed through a coin placed upon a glass plate, an image is impressed on the glass, which may be rendered visible by the vapors of iodine, or mercury, or even by breathing upon it. Ibid.

*Corona and Beads during a Solar Eclipse.*—The appearance of the *corona,* or glory, which surrounds the moon during the time of total darkness in a solar eclipse, and the *beads* which occur prior to the period of total obscuration, and also in annular eclipses, have been imitated by Professor Baden Powell, in the following manner:—A candle is placed in the focus of a lens, placed in a screen, with an aperture of about three quarters of an inch in diameter; on the opposite side of the screen is placed an opake circular disk, of a diameter equal to, or greater, than the aperture, which may be placed at different distances, so as to produce an eclipse of any magnitude, as the spectator changes his position. When the eclipse is total, the glory is seen, and when there are cusps, the beads are seen.

Lond., Edin. & Dub. Phil. Mag., July, 1843.

*Electricity from Steam.*—Professor Farraday has successfully traced the electricity from steam to the friction of particles of water against the exit pipes. Wood is the best material for the nozzle, when it is intended to show the production of electricity by the escape of steam. The source of lightning cannot be, in his view, the condensation of vapor. Ibid.

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FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

## *Hasty Generalizations in Science.*

To the Committee of Publications:

*Gentlemen,*—At this time, when scientific investigation is going on with so much activity, a proneness to hasty generalizations appears to prevail in many quarters, calculated to injure, rather than serve, the progress of science. Regretting to see a spirit of this sort in a writer, often appealed to, on the important questions of meteorology agitating at the present time, I send you a brief notice of a recent paper by him, in Poggendorf's Annals, with the hope that you will send the number of your journal to Berlin, that he may see how such things look in *abstract.*

*Meteorological Deduction.*—Professor Dove, of Berlin, has the following assertion in a recent meteorological paper, read before the Academy of Berlin, and published in Poggendorf's Annals. "The peculiar relation [of distribution of temperature] belonging to continents, is not to be found in America." Then is America not a continent, or else the relations to which the Berlin philosopher refers, are not peculiar to continents. The same philosophical spirit is manifested in Professor Dove's remarks in regard to Mr. Espy's theory of storms: "and as Espy has done, see an upward current as draught-leader (zugführer) at the top of a whirlwind, but a glance merely at the storm-charts of Redfield and Reid, is sufficient to show how unnatural the supposition is." Important questions of meteorology dependant upon a glance at a chart, and American meteorology not continental. The journals quoted in the course of the paper, are Captain Parry's at Melville Island; "Ancasters, between Ontario and Erie," of five years Observations at St. Johns, Newfoundland; and of Observations at Cambridge, Massachusetts. The sweeping conclusions from such insufficient data suit well with the neglect of numerous published registers of authority, but the extraordinary selection of localities from which to form a judgment, could hardly be expected from any one claiming to be a meteorological authority.

## M. Clement's Nautical Inventions.

*On the Sillomêtre, Sub-Marine Thermometer, Steam Indicator, Derivomêtre, and External and Internal Thermometer.—Communicated by* Captain Washington, R. N.

Before proceeding to give a description of these instruments, and particularly of the Sillomêtre of Mous. L. Clément, of Rochefort, some account of which appeared in the May number of the Nautical Magazine, it may be as well to state briefly what has been done in former times, as to finding a substitute for the common log, which it must be confessed, is a sufficiently primitive method of measuring the speed of a ship.

1. It is said that as far back as the time of Augustus, it was proposed by Vitruvius, to pass an axle, or shaft, through the side of a ship, having a wheel at each extremity; from the inner wheel a stone fell at each revolution, and the number of stones determined the rate of the vessel's speed.

2. The Marquis De Poleni, who gained a prize from the French Academy for his invention, about the year 1720, proposed to tow a globe at the end of a long line, connected with a lever, which raised a weight at its other extremity, and pointed out the speed on a graduated arc.

3. M. Pitot proposed a machine composed of two glass tubes, the lower end funnel shaped, and bent towards the ship's head, in which the water rose according to the rate of the vessel's going.

4. M. Saverien proposed a globe about four feet below the surface of the water fixed at the end of a long lever, the upper end to raise weights according to the degree of tension, and thus give the rate.

5. The *Marine Surveyor* of Henry De Saumerez, of Guernsey, on being towed astern of a ship, acquired a rotary motion which was communicated to a machine of clock-work on board, whence the rate was shown on a dial.

6. Russel's *Perpetual Log* was a spiral machine towed astern much on the same principle as that of De Saumarez.

7. Foxon's *Log*, also perpetual, was very similar.

8. The *Navivium*, by Joseph Gilmore, was composed of a wheel and pinion fixed to the keel of a ship; its movement was communicated to clock-work within, by means of a metal rod.

9. Gotlieb's *Perpetual Log* is an instrument nearly similar, with the addition of a box to guard the exterior wheel-work.

10. The *Nautical Dromometer*, of Benjamin Martin, is an instrument of the same kind, only to be fixed to the side of a ship.

11. Hopkinson, of Philadelphia, proposed a metal lever, with a circular plate at the lower end, against which the water acted, and was regulated by a spring, an index showing the rate of the ship in degrees on a graduated arc.

12. Bouguer, the companion of De la Condamine, in his voyage to Peru, proposed a globe, of 6 or 7 inches diameter, to be towed astern, the other end of the towing line to be connected with a lever which should raise weights according to the rate of sailing.

13. The *Hydroscope* of Count De Vaux, proposed in 1803, consists of one or more globes of six inches diameter sunk in the water, level with the keel, passing through a vertical copper pipe, as near the centre of gravity of a ship as may be; the globe is connected by a brass chain with the end of a horizontal lever, the other end of which communicates with a brass slide attached to a spiral spring; this spring is intended to measure exactly the force of the resistance the globe meets with in passing through the water, which is rendered into knots on a dial, and thus shows the rate of a ship's sailing, or the rate of current when at anchor.

14. An addition to this instrument, by the Count De Vaux, was to show the amount of distance run, by a comparison between two clocks, or, as he preferred, a *clepsydra*, or sand glass, which ran out once in 60 miles, when it required to be refilled; this machine would give the whole distance run, as well as the rate of sailing.

[Captain Beaufort carried out the former of these two plans, we believe, and had it fitted to his boat, during his well known and admirable survey of the coast of Karamania, in 1812.]

15. Massey's *Patent Log*, on the same principle as the Marine Surveyor of De Saumarez, is too well known to need a description, and as far as our experience goes, shows the distance run correctly.

16. The *Marinodometer* of Captain Arthur Bingham, R. N., which, in 1824, he fitted to the keel of the Tourist steamer, was somewhat similar to the *Navivium* of Gilmore, as far as we can learn.

17. A plan not unlike that of M. Pitot, (No. 3.) was fitted to the Rhadamanthus steamer, Captain George Evans, R. N., in 1830, we believe, but was not found to answer.

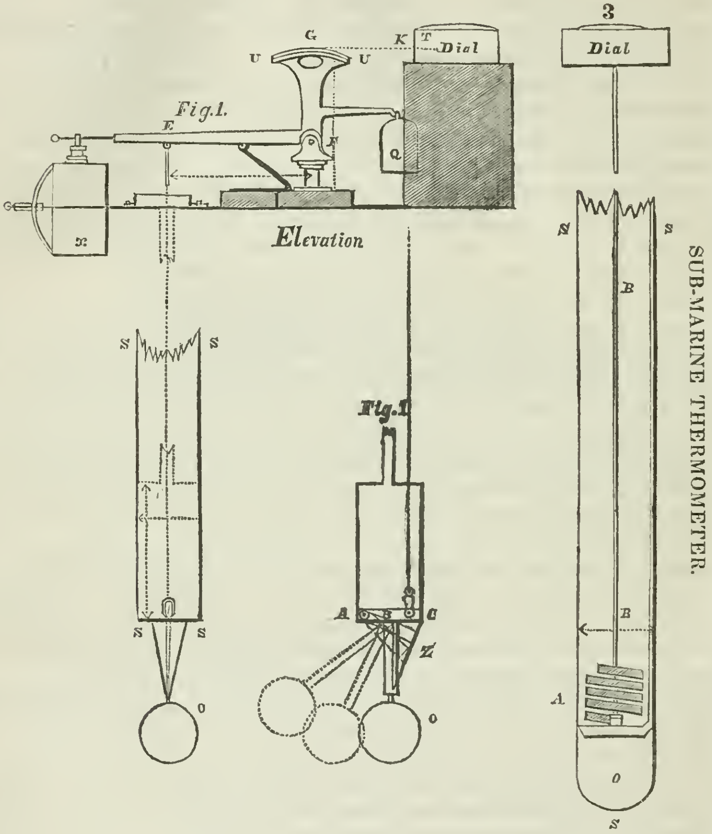
18. Mr. Purcell, of Hamburgh, in 1841, proposed a square plate, or vane, to be fixed under water at the lower end of a metal rod, the upper end connected with a spring; the amount of torsion is shown on a dial by an index.

19. Ayre's *Patent Log* consists of a small pear-shaped ball towed astern at the end of a line, the other is carried over a heavy roller

which it turns according to the amount of tension, an index showing the resistance in knots.

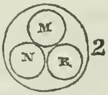
Lastly. The *Sillomêtre* of M. Clément, which we now propose to describe in detail.

*Sillomêtre.*

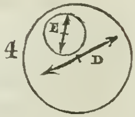


Q, Compensation weight.
*x*, Box for oil.
Z, Shield.

Dial.



Dial.



The name, *Sillomêtre,* is composed of the two French words *Sillage* (headway,) and *mêtre* (measure,) and might be well rendered in English, speed-gauge. This instrument consists of a hollow copper ball, fig. 1, about five inches in diameter, suspended under the ship's bottom, nearly amidships, from the middle of a bent lever, A, C, about five inches long; one end of this lever moves on a joint, A, its fulcrum, attached to the lower end of a metal rod which passes vertically through a copper tube, carried from the deck through the bottom of the ship near the keel; at the other end of the lever is attached a chain, C, which leads upwards, and acts upon a second horizontal lever, E, F, on deck. This second lever corresponding to the lower one, gives motion, by means of a spring, to an index, which marks on a dial, the speed of the ship expressed in knots, and tenths of a knot.

Such is the whole of the apparatus of the simple Sillomêtre. It will be readily understood, that, as the vessel moves through the water, the fluid acts upon the ball, which being circular, always presents the same section, and causes it to move aft, thereby depressing the fore end of the lever, which, by the chain, communicates with the dial on deck. The scale, by which to graduate the knots on the dial, was found by M. Clément after numerous experiments. This instrument in its simple form, shows the speed of the vessel, not the amount of distance run.

The Compound Sillomêtre consists of the same mechanism, with this addition, that the power which moves the index is applied at the same time to a watch, and accelerates its movements in proportion to the intensity of the moving power, or as the vessel quickens her speed.

A second watch is placed by the side of the first, in order to show how much the former gains upon the latter; and knowing that for every 6 seconds of gain, the vessel will have made a mile, it is easy to know the distance run.

It is evident that this compound instrument is very superior to the simple one, but its accuracy depends upon the regular going of two good watches, a result not very easily obtained at sea.

The *Sub-Marine Thermometer* is a very delicate instrument composed of a ribband formed of two metals of unequal contraction and expansion, as platina and silver, and rolled in the form of a helix, A, fig. 3, round an axis, B, which turns as the temperature of the water varies. This motion by a train of wheels and pinions is immediately communicated to two pointers on a graduated dial on deck, and which may be read off easily to hundredths of a degree.

The whole of this apparatus is enclosed in a metal tube, which passes through the bottom well aft in the run of the ship. The helix, or thermometer, is, therefore, always at a certain depth in the water, say 10 feet below the surface; and it shows instantly every change in its temperature.

As few observations have been regularly made on the temperature of the water of the sea at a certain depth, this machine may lead to some novel results.

The *Steam Indicator* points out the temperature and consequent pressure of the steam in the boilers. It is composed of a ribband, or blade, of two sensitive metals of unequal expansion, turned in a spiral form; one end is fixed to the tube, or pipe, in which it is contained, the other connected with a spindle bearing the pointers which indicate the temperature of the steam on a dial on deck, in degrees and tenths of a degree. This instrument is connected, by a small pipe, with the boiler, or steam chest, through which the steam reaches the spiral, which instantly causes any variation in temperature to be shown by the dial on deck: in high pressure engines this may be found useful.

The *Derivometer* is an instrument somewhat on the principle of the Sillomêtre, and intended to measure the drift of a ship; this is done by a vane placed on the keel, connected by a rod with a dial—the vane, of course, takes the opposite position to the drift of the vessel, which is communicated by the turning of the rod to the pointers on the dial on deck.

The *Internal and External Thermometer*, as its name indicates, is a highly sensitive thermometer, so placed against the wall of an observatory, or house, as to show the temperature of the air within and without. The two pointers, which mark this, are on the face of the same dial.

We believe that Her Majesty has ordered such an instrument to be placed in one of the apartments in Buckingham Palace.

We now proceed to the trial of the first named three of these instruments, as fitted on board H. M. S. *Blazer*, in April last.

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## REPORT.

*Monday*, 3rd April, 1843.—H.M. steam vessel *Blazer*, having been fitted with three newly-invented instruments by M. Clément, of Rochefort, namely, a Sillomêtre, to measure the rate of speed,—a Steam Thermometer, to indicate the temperature of steam in the boilers,—and a Sub-Marine Thermometer, to show the temperature of the sea at 10 feet below the surface, was directed to proceed down the river, on trial, having on board M. Clément, the inventor, Mr. Cary, who had constructed the present set of instruments, and Mr. Large, of Woolwich Dockyard, who had superintended the fitting of them in the vessel.

Before starting, made a trial under the superintendence of Mr. Lloyd, chief engineer, of Woolwich Dockyard, of the temperature of the steam by the steam thermometer, as compared with the elasticity of the steam, as shown by the steam gauge, at each lb. pressure: making due allowance for the height of the barometer, and using the temperature as given in Dalton's experiments, corresponding to the inches of mercury in the steam gauge. The results obtained were as follows:—

| | Steam Ther. Centi. | | Inches. |
|---|---|---|---|
| At $5\frac{7}{8}$ lbs. pressure, 1st exp. | 110.4 | Barometer. | 29.85 |
| " 2nd do. | 110.2 | Hei't of steam gauge, | 10.25 |
| Mean, | 110.3 | | |
| Temp. by Dalton's tables, | 108.7 | | 40.10 |
| Difference, | 1.6 | | |

| | | | |
|---|---|---|---|
| At 3 lbs pressure, 1st exp. | 107.0 | Barometer. | 29.85 |
| " 2nd " | 107.0 | Height of steam gauge. | 6.00 |
| Mean. | 107.0 | | |
| Temp. by Dalton's tables. | 105.2 | - . - - | 35.85 |
| Difference. | 1.8 | | |
| At 1 lb. pressure, 1st exp. | 103.3 | Barometer. | 29.85 |
| " 2nd " | 103.3 | Height of steam gauge, | 2.00 |
| Mean. | 103.3 | | |
| Temp. by Dalton's tables. | 101.7 | - - - - | 31,85 |
| Difference. | 1.6 | | |
| At 4 lbs. pressure, 1st exp. | 108.4 | Barometer. | 29.85 |
| " 2nd " | 108.4 | Height of steam gauge. | 8.00 |
| Mean. | 108.4 | | |
| Temp. by Dalton's tables. | 106.9 | - - - - | 37.85 |
| Difference. | 1.5 | | |
| At 2 lbs. pressure, 1st exp. | 105.4 | Barometer. | 29.85 |
| " 2nd " | 105.3 | Height of steam gauge. | 4.00 |
| Mean. | 105.3 | | |
| Temp. by Dalton's tables, | 103.4 | - - - - | 33.85 |
| Difference. | 1.9 | | |
| At 0 pres. safety valve open. | 101.3 | Barometer. | 29.85 |
| Temp. due to height of barom. | 99.7 | | |
| Difference. | 1.6 | | |

Tested also the Sub-Marine Thermometer by sinking one of Newman's Standard Thermometers 10 feet below the surface of the water, and keeping it there half an hour. At high water the temperature by M. Clément's Sub-Marine Thermometer was 45°.9; by Newman's Mercurial Thermometer 40°.0. Temperature of air 47° Fahrenheit.

Tried also on shore in the dockyard, by a quadrant, the angles at which the centre of the ball of the Sillomètre would stand when the index marked different knots on the dial, and found as follows:

The ball left to hang, with the chain loose, being in the position taken in the water when at rest.

| | | | | |
|---|---|---|---|---|
| The chain tight, | 0 | deg. on quadrant. | 0 | knots on dial. |
| " | 10 | " | 0 | " |
| " | 15 | " | 2.2 | " |

| | | | |
|---|---|---|---|
| The chain tight, | 20 deg. on quadrant. | 4.5 | knots on dial. |
| " | 25 " | 6.6 | " |
| " | 30 " | 8.6 | " |
| " | 35 " | 10.3 | " |
| " | 40 " | 11.5 | " |
| " | 45 " | 12.1 | " |
| " | 50 " | 12.8 | " |

## *Passage from Woolwich to the Nore.*

| Time. | Rate of going. | | Steam Thermometer | | Sub-marine Thermomt'r. | | Dp. wr. | T'm. air. | Remarks, Monday, April 3, 1843. |
|---|---|---|---|---|---|---|---|---|---|
| P. M. h. m. | Sillom. | Log. | Centi ° | Fahrn. ° | Centi ° | Fahr. ° | fm | ° | |
| 3 45 | 5.8 | | 110.5 | 230.90 | 9.40 | 48.92 | 5½ | 59 | At 3h. 45m. started from Woolwich, |
| | 6.7 | | | | | | | | moderate breezes and fine; wind |
| 4 0 | 6.1 | | | | 9.20 | 48.56 | | | W.S.W. 2; barometer 29.80. |
| | 6.4 | 6.2 | 110.0 | 230.00 | 9.25 | 48.65 | 6 | | High water; draught of water for- |
| | 6.2 | | | | | | | | ward 11 ft. 4 ins., aft 11 ft. 8 ins. |
| | 6.6 | | 109.6 | 229.28 | | | | | Boilers filled with fresh water. |
| 4 15 | 6.4 | | | | 9.02 | 48.04 | 5¾ | | Sillomêtre put in action just abreast |
| | 8.2 | | 110.1 | 230.18 | | | | | the Dockyard. |
| | 6.0 | | 109.8 | 229.64 | | | | | Adjusted the chain to the rate shown |
| | 5.5 | | | | | | | | by the common log. |
| | | | | | 8.85 | | 6¼ | | Altered the helm continually to |
| 4 30 | 6.8 | | 110.1 | 230.18 | | 47.93 | | | avoid vessels in streaming down the |
| | 5.0 | | | | | | | | river; at each spoke of the wheel the |
| 4 45 | 7.5 | | 110.1 | 230.18 | 8.75 | 47.75 | 7½ | | Sillomêtre showed a decrease of rate, |
| | 6.0 | | 110.7 | 231.26 | 8.60 | 47.48 | 8 | | when put hard over the speed fell |
| | 6.2 | | | | | | | | from 7 knots to 4. |
| 5 0 | 6.2 | 6.2 | 109.5 | 229.10 | 8.55 | 47.39 | 8½ | 56 | At 4h. 20m. the Sillomêtre showed |
| | 6.6 | | 109.8 | 229.64 | | | | | a speed of 8.2, which is certainly be- |
| 5 15 | 5.9 | | 109.0 | 228.20 | 8.48 | 47.25 | 7¼ | | yond the power of the vessel. |
| 5 30 | 6.2 | | 108.8 | 227.84 | 8.42 | 47.16 | | | At 4h. 30m. put over Massey's Log. |
| | 6.8 | 7.0 | | | 8.30 | 46.94 | | | At 5h. off Greenhithe. Variations of |
| | 6.9 | | | | | | | | speed as shown by Sillomêtre, 5.4 |
| | | | | | | | | | while heaving the common log, 5.6 |
| | | | | | | | | | " " 5.8 |
| | | | | | | | | | " " 6.0 |
| | | | | | | | | | " " 5.6 |
| | | | | | | | | | " " 5.8 |
| 5 45 | 5.6 | | 108.5 | 227.30 | 8.32 | 46.98 | 9 | | |
| | 6.5 | | | | | | | | Mean, 5.7 |
| 6 0 | 6.2 | | 109.5 | 229.10 | 8.30 | 46.94 | 7 | 52 | |
| 6 15 | 6.5 | | 108.9 | 228.02 | 8.25 | 46.85 | 6½ | | |
| 6 30 | 6.0 | 5.8 | 109.7 | 229.46 | 8.20 | 46.76 | 7 | | At 5h. 45m., in 9 fathoms, the Sub- |
| | 5.8 | | | | | | | | marine Thermometer indicated no |
| 6 45 | 6.8 | | 109.4 | 228.92 | 8.22 | 46.80 | 5¼ | | difference of depth. At 6h. off Sheer- |
| 7 0 | 6.3 | | 109.5 | 229.10 | 8.13 | 46.64 | 5¼ | 51 | ness. In 2¾ hours, Massey's Log |
| 7 15 | 6.5 | | 109.7 | 229.46 | 8.10 | 46.58 | | | showed a distance of 21.6, which |
| | 6.4 | | | | 8.08 | 46.56 | | | exceeds that given by the Sillomêtre, |
| | | | | | | | | | or common log. |
| | | | | | | | | | At 7h. 30m. anchored at the Nore. |
| | | | | | | | | | Tried the temp. of water by Mercu- |
| | | | | | | | | | rial Thermometer, and found it to |
| | | | | | | | | | agree exactly with M. Clément's |
| | | | | | | | | | Sub-marine Thermometer, namely, |
| | | | | | | | | | 46°.5. |

The Sillomêtre throughout this passage was very sensitive, showing immediately the change of rate due to a single spoke of the wheel.

The Steam Thermometer varied regularly with the temperature of the steam as shown by the steam gauge, but generally stood 3° of Fahrenheit, in excess.

The Sub-marine Thermometer showed a gradual decrease of temperature as we approached the sea, which was unexpected, but it agreed exactly with the best mercurial thermometers.

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*Remarks.*—It will be seen from the above table, that the Sillomêtre showed every variation in the speed of the vessel, even the alteration caused by a single spoke of the helm was perceptible, and putting the helm hard over, caused the ship to lose half her way almost immediately; as the dial of the instrument is placed on deck, and the index, or pointer, very conspicuous, the officer of the watch, without any trouble, may observe it at every turn he takes on the quarter deck; and it is obvious that none but the most inattentive person can fail to have a much more correct knowledge of the rate of the vessel's going, than he can from heaving the common log once or twice an hour. The Sillomêtre will also enable an officer easily to ascertain the best trim of a vessel; the difference caused by shaking out a reef, or by making, or shortening, sail; and in a fleet would enable a ship to keep her station by night, or by day, with great steadiness; and lastly, it impresses very strongly, on the observer, the absolute necessity of good steering, and giving very little helm when in chase, or on a trial of sailing, or at any other time when speed is of importance.

The *Steam Thermometer* has also a dial placed on deck, so that the officer of the watch can tell at any moment whether there is a sufficiency of steam, or the contrary, and can thus check the wasteful expenditure of coal; it would point out, too, the possible, but highly improbable, occurrence of no water in the boilers, or an undue increase of the temperature of steam from any other cause. Its chief value, however, would be shown in a high pressure engine, when it would give, immediately, warning of any approach to such a degree of temperature, or pressure, as might be dangerous.

The *Sub-marine Thermometer* remains constantly at a depth of about ten feet below the surface of the water, and owing to its being formed of platina and silver, is extremely sensitive, and thus every change in the temperature of the sea will be shown at once on the dial on deck.

As in the Atlantic Ocean, and in other deep seas, the deep water is said to be warmer than the shallow, it probably would there show, by mere inspection, the approach to shoals, rocks, or land, and serve as an excellent warning. At this season of the year, however, in the shallow waters of the North Sea, we observed no such effect, on the contrary, the temperature of the water gradually decreased from 50° Fahrenheit, at Woolwich, to 44½°, at about twenty miles to the eastward of the North Foreland, and as gradually increased on our return to the same point.

Possibly as the summer advances this may be different, and, in order to discover when the change of temperature takes place, I have directed the instrument to be registered every two hours night and day. As the Thermometer is highly sensitive, and may be read off with ease to hundredths of a degree, and agrees perfectly with the best mercurial thermometers, it many possibly furnish some novel results of value to the philosopher, as well as to the navigator, since I am not aware of the existence of any continued series of observations on the temperature of the sea, at all seasons of the year.

I would venture to recommend that the instruments, after coming from the hands of the maker, should be put to the severest test by competent persons before being finally placed in a ship.

The instruments fitted on board the *Blazer*, appear to be carefully made and well finished; they are conveniently and securely placed in the ship, nor does there seem to be any fear of their being deranged.

*Harwich, April 12th,* 1843. Lond. Naut. Mag.

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TRANSLATED FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

## *Electro Chemical Silvering.*

A report made by M. Becquerel, in his own name, and in those of M. Dumas, and Hericourt de Thury, to the Academy of Sciences of Paris, session of July 10th, 1843, upon a communication made by M. Mourey, concerning an useful modification of the processes hitherto used in electro-chemical silvering. Heretofore the articles silvered by the electro-chemical process have been, indeed, when first taken from the apparatus, of a perfect mat-white, which, however, they soon lost, and in a few days their surface became of a dirty yellow, which diminished their value. If we endeavored to color them as in gilding, the silvering was injured. The process of M. Mourey is intended to avoid this difficulty. In electro-chemical silvering, as in all the decompositions effected by means of electricity, the article which is covered with silver attracts to itself, at the same time, all the electro positive elements which are in the solution, so that in the case before us, there is a sub-cyanide of silver, a compound upon which light acts to change its color. The object then is to destroy this compound without the use of acids. M. Mourey has succeeded in this by a very simple process. He covers the articles several times with a solution of borax, and then submits them to a temperature so high that the borax begins to melt, then plunges them into water acidulated with sulphuric acid, and suffers them to remain some time. The articles when washed and dried acquire the most beautiful lustre which virgin silver can take. This lustre remains so long as the articles are not exposed to sulphurous vapors.

## *Galvanic Bronzing.*

M. Becquerel again exhibited to the Academy, new specimens of his metallic applications. In communicating, at the last session, the process by means of which the peroxides of lead and of iron may be applied to the surface of metals, so as to preserve the oxidizable ones from ultimate injury, he had remarked that it was possible so to vary the colors of the coatings, as to present effects agreeable to the eye, which might be of use in the arts. Wishing to satisfy himself as to the extent to which this might be carried, M. Becquerel multiplied his experiments, and arrived at remarkable results. He has obtained various and brilliant tints, which he compares to those presented by the wings of tropical beetles. The articles which receive these tints acquire more brilliancy when they are rubbed with leather and jewellers' rouge; that is, the coatings which produce them have a strong adherence—the bronzing rendering the surface more brilliant, determines the reflection of a greater quantity of light, and, consequently, must increase the brilliancy of the color.

The principle upon which the coatings are formed, is, that whatever be the surface of the metal, such will be the deposited coat, so long as it is thin; but as the deposit takes place when the metal is electro-positive, that is when the oxygen tends to oxidize the surface, (if the metal be oxidizable) the coloring effects are only produced with non-oxidizable metals, such as gold, or gilded copper, the surface of which is brightly polished. Thus gold is the metal upon which the rich colors, shown by M. Becquerel to the Academy, were deposited. These effects were produced only by the solution of protoxide of lead in potassa. It requires but one or two pairs of plates, but the operation must be carefully watched, for it lasts sometimes not more than a minute. The colors obtained are light-red, flame-red, deep-red, violet-blue, and finally, a very deep color. The articles must be continually withdrawn from the bath, in order to obtain the tint wished for. If the action be too strong, the hydrated peroxide of lead is formed, which is precipitated in yellow floculi through the solution, without the production of the colors. It is, therefore, necessary to watch the operation every instant, which is so easy, that a number of articles may be operated on at the same time, and always with the same success. M. Becquerel has hitherto confined himself to the effects produced by oxides of lead and iron; in another communication he will give the results obtained with other oxides.—*L'Inst.*

### *A new and easy method of covering Copper and Brass with Platina.*

One part of solid chloride of platina is dissolved in 100 parts of water, and to this solution is added 8 parts of common salt; or, still better, 1 part of platino-chloride of ammonia, and 8 parts of hydrochlorate of ammonia are placed in a flat porcelain vessel, 32 to 40 parts of water poured over it, the whole heated to boiling, and the vessels of copper or brass, perfectly bright, are placed therein. They will be covered in a few seconds with a brilliant and firmly adhering layer of platina.

There is no doubt that this method may be employed with the greatest advantage in pharmaceutical laboratories.

Annals of Chemistry.

### *On Tinning and Zincing Copper and Brass by the moist way.*

Plates of copper, or brass, placed in a boiling solution of stannate of potassa mixed with turnings of tin, are, in the course of a few minutes, covered with a firmly attached bright layer of tin—a method very useful for tinning pharmaceutical instruments.*

A layer of zinc may also be obtained on the same metals by employing chloride of zinc: pure zinc turnings being present. The same object can be attained by means of zinc, and a solution of hydrochlorate of ammonia.—*Boettger's Beitrage.* Ibid.

### *On colored Fires.*

There are very many receipts for colored fires, differing in some slight degree from each other. The following, I believe, *from experience,* to be the best:—

*Red fire.*—Sulphur, 1 ounce; sulphuret of antimony, 1 ounce; chlorate of potass, 1 ounce; nitrate of strontian, 5 ounces. The chlorate of potass, being previously well powdered, should be mixed carefully on a paper with the sulphuret of antimony, and afterwards the remaining ingredients should be added, and well mixed with a spatula on paper.

*Blue fire.*—Nitrate of barytes, 77 parts; sulphur, 13 parts; chlorate of potass, 5 parts; realger, 2 parts; charcoal, 3 parts. Mix them thoroughly.

*Purple.*—Lamp black, 1 part; realger, 1 part; nitre, 1 part; sulphur, 2 parts; nitrate of strontian, 16 parts; chlorate of potass, 5 parts.

Ibid.

### *Researches on certain circumstances which influence the temperature of the Boiling Point of Liquids.* By M. F. Marcet.

Philosophers generally admit that the temperature at which any liquid enters into ebullition, depends, 1st. On the nature of the liquid;

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* "The same experiment," remarks Mr. Wittztein, "was performed by Trommsdorff fifty years ago." I will here give his own words (in Götting's Taschenbuch für Scheidekünstler, and Apoteker Jahrgang, 1791, s. 128,) on this subject.

"*Singular Tinning by the moist way.*—Several vessels of pure English tin were boiled in a portion of caustic ley, in order to clean them. The ley was decanted, and remained standing during one night, in a copper kettle, for further use. The following day, when the kettle was employed, the surface of it, so far as it had been covered by the ley, was discovered to be tinned; and the kettle was used for a long time before this tinning was worn out. Although this might not prove a very economical means for tinning vessels, it might, perhaps, be employed with advantage in those vessels, the shape of which does not admit of their being tinned in the common way."

Further, he states, in the same work, in the year 1792, p. 193:—

"Last year I announced to the public the observation, that caustic fixed vegetable alkali dissolves zinc by the moist way, and is precipitated therefrom in a metallic form by copper: I have since repeated the experiment with complete success. Caustic mineral alkali, and volatile mineral alkali, show the same phenomenon, but it does not always succeed so well as with vegetable alkali."—*Buchner's Repert.*

2nd. On the atmospheric pressure; 3rd. On the nature of the vessels in which ebullition takes place. It is to this last point that M. Marcet has particularly directed his attention; and after an immense number of experiments, he has arrived at the following conclusions:—1st. That the boiling point of water, in glass vessels, varies between 212.54° and 215.6°, according to different circumstances, and particularly according to the quality of the glass employed. In every case the temperature of the steam furnished remained sensibly the same, and is constantly lower (the fraction of a degree) than that furnished by water boiling in a metallic vessel.

2nd. Whatever the nature of the vessel employed, the temperature of the steam furnished is always beneath that of the boiling liquid which furnishes it. When glass vessels are employed, this difference, at a medium, is 1.9° F.; if metallic vessels be employed, it varies from 0.27° F. to 0.36° F. There is only one exception to this rule, which is, when the vessel, whether of glass or of metal, is covered with a thin layer of sulphur, or shellac, or any analogous substance, having no sensible attraction for water. In this case only, the temperature of the vapor is found identical with that of the boiling liquid which furnishes it.

3rd. Contrary to the generally received opinion, a certain temperature being given, it is not in a metallic vessel that the temperature of boiling water is at the lowest possible degree; for it will be found that in a glass vessel covered with a thin layer of sulphur, shellac, or any other similar substance, this temperature is, by some fifths of a degree, lower than in a metallic vessel.

4th. In vessels made of perfectly pure glass, free from any foreign matter, water, and also alcohol, may be heated, without ebullition taking place, to a temperature much higher than has been hitherto usually believed. We may in particular obtain, in this manner, water (not boiling) heated to 221° F.: if this does not happen in every case, it will be found that the surface of the glass is not perfectly smooth, although apparently so, and that it contains foreign matters, which are adherent thereto, and which may be removed by different methods, more particularly by the action of concentrated sulphuric acid.—*Ann. de Chimie.* Ibid.

## *Test for Copper.*

Verguin observed, by chance, that copper may be disengaged, in the metallic state, from any solution containing it, by feebly acidulating the liquid with muriatic acid, and placing it in a capsule formed with platina foil: over this must be arranged a piece of tin plate in such a manner as to touch both the liquid and platina. A deposit of metallic copper on the surface of the platina ensues, which is firmly adherent, and maintains its metallic lustre. The metals should be perfectly clean.—*Ph. C. Bl.* Ibid.

## METEOROLOGICAL OBSERVATIONS FOR JULY, 1843.

| Moon. | Days. | Therm. Sun Rise. | Therm. 2 P.M. | Baromtr. Sun Rise. | Baromtr. 2 P.M. | Wind. Direction. | Wind. Force. | Water Fallen in rain | State of the Weather, and Remarks. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 71° | 92° | 29.86 | 29.86 | SW. | Moderate | | Clear. | Clear. |
| | 2 | 77 | 93 | 29.80 | 29.80 | SW. | do | .59 | Clear. | Rain. |
| | 3 | 60 | 73 | 29.75 | 29.75 | NW. | Brisk | | Clear. | Clear. |
| ☾ | 4 | 55 | 78 | 30.00 | 30.00 | W.S. | do | | Clear. | Clear. |
| | 5 | 66 | 71 | 29.90 | 29.90 | W. | do | | Cloudy. | Cloudy. |
| | 6 | 56 | 78 | 29.94 | 29.94 | W.E. | do | | Clear. | Clear. |
| | 7 | 60 | 81 | 29.95 | 29 95 | W. | do | .16 | Par. Cloudy. | Rain. |
| | 8 | 65 | 78 | 29.70 | 29.70 | W. | do | | Clear. | Clear. |
| | 9 | 66 | 83 | 29.80 | 29.80 | SW. | do | | Clear. | Clear. |
| | 10 | 67 | 79 | 29.80 | 29.80 | SW. | Moderate | | Par. Cloudy. | Cloudy. |
| ☺ | 11 | 68 | 63 | 29.74 | 29.74 | NE. | do | .55 | Par. cloudy. | Rain. |
| | 12 | 65 | 68 | 30.00 | 30.00 | NE. | do | .03 | Cloudy. | Rain. |
| | 13 | 64 | 67 | 30.16 | 30.20 | NE. | do | | Cloudy. | Cloudy. |
| | 14 | 64 | 75 | 30.20 | 30.15 | W. | do | | Cloudy. | Cloudy. |
| | 15 | 68 | 80 | 29.95 | 29.90 | W. | do | .75 | Cloudy. | Showery. |
| | 16 | 65 | 81 | 29.90 | 29.90 | S. | do | | Fog. | Clear. |
| | 17 | 68 | 74 | 29.90 | 29.90 | S. | do | | Fog. | Cloudy. |
| | 18 | 72 | 87 | 29.76 | 29.75 | W. | do | | Cloudy. | Par. cloudy. |
| ☽ | 19 | 70 | 86 | 29.75 | 29.75 | W. | do | .03 | Clear. | Rain. |
| | 20 | 62 | 76 | 29.75 | 29.82 | NW.W. | Brisk | | Cloudy | Clear. |
| | 21 | 56 | 77 | 29.87 | 29.87 | NW. | Moderate | | Clear. | Clear. |
| | 22 | 58 | 80 | 29.90 | 29.90 | W. | do | | Clear. | Clear. |
| | 23 | 64 | 82 | 29.86 | 29.86 | W.SW | do | | Lightly cloudy. | Clear. |
| | 24 | 68 | 88 | 29.80 | 29.74 | SW. | Brisk | | Lightly cloudy. | Clear. |
| | 25 | 66 | 81 | 29.90 | 29.93 | NE. | Moderate | | Par. cloudy. | Clear. |
| | 26 | 63 | 83 | 30.06 | 30.06 | W. | Brisk | | Clear. | Clear. |
| ⊗ | 27 | 68 | 89 | 29.94 | 29.94 | SW. | Moderate | | Clear. | Lightly cloudy. |
| | 28 | 79 | 90 | 29.94 | 29.90 | SW. | do | | Clear. | Clear. |
| | 29 | 76 | 92 | 29.80 | 29.76 | SW. | Brisk | | Hazy. | Par. cloudy. |
| | 30 | 76 | 82 | 29.75 | 29.67 | NE. | Moderate | .03 | Cloudy. | Rain. |
| | 31 | 62 | 66 | 29.85 | 29.90 | NE. | do | .90 | Rain. | Clear. |
| | | 65.97 | 79.70 | 29.88 | 29.88 | | | 3.04 | | |

TRERMOMETER.
Max. 93, on 2nd.
Min. 55, on 4th.
Mean, 72.87

BAROMETER.
Max. 30.20 on 13th & 14th.
Min. 29.67 on 30th.
Mean 29.88

### AUGUST, 1843.

| Moon. | Days. | Therm. Sun Rise. | Therm. 2 P.M. | Baromtr. Sun Rise. | Baromtr. 2 P.M. | Wind. Direction. | Wind. Force. | Water Fallen in rain | State of the Weather, and Remarks. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 62° | 76° | 29.90 | 29.90 | NE. | Moderate | | Cloudy. | Par. cloudy. |
| ☾ | 2 | 60 | 79 | 29.84 | 29.84 | NE.SE. | do | | Cloudy. | Par. cloudy. |
| | 3 | 64 | 81 | 29.95 | 30.00 | NE.SE. | do | | Cloudy. | Par cloudy. |
| | 4 | 65 | 81 | 30.14 | 30.25 | E. | do | | Par. cloudy. | Par. cloudy. |
| | 5 | 66 | 70 | 30.20 | 30.15 | N. | do | 3.80 | Cloudy. | Rain. |
| | 6 | 65 | 76 | 30.00 | 30.00 | W. | do | | Par. cloudy. | Clear. |
| | 7 | 67 | 78 | 30.00 | 30.00 | E. | do | .07 | Showery. | Cloudy. |
| | 8 | 74 | 77 | 29.90 | 29.90 | W. | do | | Cloudy. | Showery. |
| ☺ | 9 | 68 | 69 | 29.90 | 29.96 | E. | do | 1.65 | Rain. | Cloudy. |
| | 10 | 66 | 69 | 29.94 | 29.86 | NE. | do | .15 | Par. cloudy. | Rain. |
| | 11 | 66 | 76 | 29 80 | 29.84 | W. | do | | Cloudy. | Clear. |
| | 12 | 64 | 77 | 29.86 | 29.90 | W. | do | | Par cloudy. | Clear. |
| | 13 | 66 | 82 | 29.90 | 29.90 | SW. | do | | Hazy. | Lightly cloudy. |
| | 14 | 66 | 82 | 29.85 | 29.75 | W.SW. | do | .35 | Fog—clear. | Rain. |
| | 15 | 68 | 79 | 29.70 | 29.70 | W. | do | | Cloudy. | Clear |
| | 16 | 66 | 80 | 29.80 | 29.85 | NW. | do | | Cloudy. | Clear. |
| | 17 | 66 | 81 | 29 85 | 29.90 | SW. | do | | Fog. | Clear. |
| ☽ | 18 | 69 | 83 | 29.85 | 29.85 | SW. | do | | Fog. | Clear. |
| | 19 | 71 | 81 | 29.85 | 29.85 | SE. | do | .15 | Cloudy. | Rain. |
| | 20 | 68 | 78 | 29.85 | 29.80 | E. | do | | Par. Cloudy. | Clear. |
| | 21 | 68 | 78 | 29.85 | 29.84 | E. | do | .70 | Cloudy. | Showery. |
| | 22 | 70 | 77 | 29.84 | 29.84 | W.E. | Calm | .49 | Rain. | Par. cloudy. |
| | 23 | 70 | 76 | 29.86 | 29.86 | W. | do | .05 | Cloudy. | Rain. |
| | 24 | 65 | 78 | 29.88 | 29.90 | W.NE. | do | | Cloudy. | Clear. |
| ⊗ | 25 | 66 | 79 | 29.98 | 29.98 | NE. | do | | Cloudy. | Clear. |
| | 26 | 68 | 80 | 30.00 | 30.00 | SW. | Moderate | | Cloudy. | Clear. |
| | 27 | 68 | 82 | 30.00 | 30.00 | SW. | do | | Cloudy. | Clear. |
| | 28 | 72 | 77 | 30.00 | 30.00 | SW. | do | .40 | Cloudy. | Rain. |
| | 29 | 70 | 80 | 30.00 | 30.05 | NE. | do | | Cloudy. | Par cloudy. |
| | 30 | 71 | 82 | 30.05 | 30.00 | E. | do | | Cloudy. | Clear. |
| | 31 | 72 | 86 | 29.94 | 29 80 | W. | do | | Par. cloudy. | Clear. |
| | | 67.32 | 78.36 | 29.92 | 29.92 | | | 7.81 | | |

THERMOMETER.
Maximum 86 on 31st.
Minimum 60 on 2nd.
Mean, 72.34

BAROMETER.
Max. 30.25 on 4th.
Min. 29.70 on 15th.
Mean, 29.92

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# Civil Engineering.

## *Cost of Transportation on Railroads.* By Charles Ellet, Jr., C.E.

(Continued from Page 324.)

### *Repairs of Engines and Cars.*

It is the custom of many companies to publish the cost of repairs of their cars and engines in a single item, so as to make it impossible for the reader to determine, from their accounts, what portion of the bill was created by the engines, or the difference between the repairs due to different sorts of cars; but still an industrious investigation of the subject gives us facts enough to estimate these separate items for ordinary cases, with all desirable accuracy. I have stated in a former paper that the repairs of burthen cars are worth, on the average, 4½ mills per ton per mile; and that the repairs of the engines averaged, during the year 1842, *seven* cents per mile run. I have also observed that the repairs of passenger cars vary from three-fourths of a mill to a mill and a half, and sometimes exceed 2 mills per passenger per mile. If these facts—all of which enter into the formula which I have offered for the determination of the aggregate annual expenses of a railroad company—be well established, they will not only stand the test of trial for the aggregate, but they will apply in detail. Not only should the formula for determining the aggregate expenses be correct, and correspond with actual results—as we have seen—but the separate items of which it is composed, must, likewise, bear the test, and give results in agreement with the average results of experience.

It is not pretended that a formula could be offered which would show the exact cost of every item of every company for every year—because the actual expenditures due to each item fluctuate from year to year; but it is maintained that these fluctuations are above and below a certain average line, from which they may depart towards either side for a certain time, but to which, and beyond which, on the opposite side, they are as sure to come as the pendulum is sure to approach the vertical in its vibrations. Although it was not my intention to enter so minutely into these details, probably more confidence will be yielded to my statements when the data on which they are founded are presented. These data, for the repairs of engines, are exhibited in the following

*TABLE.*

| Name of Roads. | Year | Miles run by engines. | Cost of repairs of engines. | Repairs pr mile run. | Remarks. |
|---|---|---|---|---|---|
| Philada. Wilm. & Balt. | 1842 | 177,859 | $ 17,071 | 9.6Cts. | Old Road. |
| Western Road, | 1842 | 397,295 | 24,177 | 6.1 | New road. |
| Georgia Road, | 1842 | 152,873 | 10,155* | 6.7 | Ordinary & extraord'y repairs & improvem's. |
| Balt. & Susquehanna, | 1842 | 128,349 | 7,193 | 5.6 | New road. |
| Utica and Schenectady, | 1842 | 150,000 | 10,346 | 6.9 | Passenger business. |
| Baltimore and Ohio, | 1841 | 299,617 | 20,640 | 7.0 | Old roads in good condition. |
| Baltim'e and Washing'n, | 1842 | 95.817 | 7,973 | 7.2 | |
| Philada. & Columbia, | 1842 | 261,744 | 21,915 | 8.4 | Generally frei't business. |
| Boston and Providence, | 1842 | 112,805 | 7,257 | 6.5 | Old roads in good condition. |
| Baltimore and Ohio, | 1843 | 509,765 | 35,941 | 7.0 | |
| Wash. and Baltimore, | 1843 | 96,716 | 6,714 | 7.0 | |
| | | 2,382,840 | $ 169,380 | Avr.7.1 | |

This table exhibits the cost of repairs of engines which have traversed a space of 2,382,840 miles; and shows that the average is within one-tenth of a cent, per mile run, of the mean value at which I had stated it. It is my impression, however, that the average on these same roads will be greater for the year 1843.

Now, if we call N the number of miles traveled by the locomotive engines; T the number of tons of freight carried one mile; and P the number of passengers carried one mile, the average aggregate cost of repairs of passenger and burthen cars, and locomotive engines, will be shown, very nearly, by the formula,

$$\frac{7N}{100} + \frac{4.5T}{1000} + \frac{P}{1000}.$$

By expressing the cost of repairs in this way, we are able to determine, at once, the expenses of repairs for an entire train composed of either description of cars, or of both sorts, and in any proportions.

Although this, and all my other, estimates might be much strengthened, by bringing forward facts resulting from former experience, I prefer, with one or two exceptions, to limit my examples, on this occasion, to those works of which I have obtained authentic information for the year 1842. Of course, I exclude those lines which have been so recently completed, as to require no repairs at all for cars.

The following table presents the number of miles run by locomotive engines, and the number of tons and passengers carried one mile on eight railroads for the year 1842, and two for 1843—which have been recently published;—and in the two last columns will be seen the actual expenses of repairs of cars and engines, and the expenses of the same computed by the formula.

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* This Company have added to the usual division of their expenses into ordinary and extraordinary repairs, the new classification of "improvements to engines;" not being able to conceive that a small stock of engines could run 153,000 miles, and be materially improved by it, I regard these "improvements" as *expenses.*

*TABLE.*

| Name of Road. | Year | Miles run by engi's. | Tons carried one mile. | Passengers carried one mile. | Actual cost of repairs. | Comput'd cost of repairs. |
|---|---|---|---|---|---|---|
| Petersburg Road, | 1842 | 131,160 | 1,342,000 | 976,000 | $ 16,513 | $ 16,196 |
| Boston and Providence, | 1842 | 120,000 | 890,400 | 4,919,418 | 13,506 | 17,326 |
| Baltimore and Ohio, | 1841 | 299,617 | 3,647,093 | 2,495,911 | 45,534 | 39,881 |
| Baltimore and Ohio, | 1842 | 334,519 | 3,985,425 | 2,738,779 | 44,568 | 44,189 |
| Baltimore and Ohio, | 1843 | 509,765 | 7,109,310 | 6,062,455 | 62,862 | 73,738 |
| Baltim. and Washington, | 1843 | 96,716 | 805,429 | 2,646,719 | 17,453 | 14,801 |
| Baltimore and Susque'a., | 1842 | 128,349 | 1,610,000 | 1,165,000 | 13,370 | 17,390 |
| Balt. and Washington. | 1842 | 95,817 | 877,138 | 3,188,948 | 17,053 | 13,864 |
| Utica and Schenectady, | 1842 | 150,000 |  | 8,413,704 | 18,842 | 18,914 |
| Boston and Lowell, | 1842 | 143,607 | 2,442,102 | 4,675,294 | 28,816 | 25,716 |
| Georgia Road, | 1842 | 152,873 | 1,475,000 | 1,770,000 | 19,899 | 19,107 |

On inspecting this list we will observe that the actual charges on some of the roads are a little above, and on others a little below, the indications of the formula—but that the deviations are in no instance too wide to render the rule, as far as it goes, a safe test of the value of an investment. The actual cost on the Baltimore and Ohio Railroad falls considerably below the computed cost for the year 1843. In 1842 the agreement was very close, and in 1841 the result was nearly as much above as that of 1843 is below the rule. Indeed, in 1841 the sum of $ 9,766 was expended for *new* burthen and passenger cars, in addition to the $ 45,534 charged to repairs of cars and engines. The aggregate expenses for repairs of cars and engines, on that work, for the three years amounted to $ 152,964—and the expenses calculated by the formula to $ 157,808. If we add the sum paid for *new cars*, to the actual cost of repairs, the actual expenses, for the three years, will be $ 162,730, or 3 per cent. above the computed expenses.

The formula simply exhibits what it is intended to show—the average for a succession of years. I do not include the Boston and Worcester road in this table, because the result on that work is entirely anomalous. For previous years the agreement between the calculation and expenses was sufficiently close; but in 1842 there was a material increase of business, an extraordinary reduction in the expense of repairing the cars and engines, and a simultaneous augmentation of the capital—or charge for construction—of $ 390,000. I am obliged to suppose that new cars and engines were added to the line, and that a portion of the business was performed by new stock.*

We may now pass to another very important division of railroad expenses, which are usually, though very improperly, denominated "extraordinary expenses." I refer chiefly to the

*Wear of Iron Rails.*—There is, perhaps, no subject of interest to the engineer which has attracted less serious attention, or has been more vaguely and indefinitely considered, than the wear of railroad iron. Instead of attempting to find some correct and rational measure of this wear, the public, and in a great measure, the profession also, have persisted in regarding the visible destruction of the iron on roads which have been some years in operation, as a consequence of the inferior quality of the particular specimen, or of the inadequate strength of the particular pattern. It is the custom to say that the mashed and splintered iron of the Camden and Amboy, and Columbia roads was bad; but no argument has ever been adduced to show that good iron, in the same situation, and subjected to the same sort of treatment, would do better.

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* The cost of repairs of locomotive engines for this road, for the year 1841, was 9½ cents per mile run, and in a space of seven years, from 1835 to 1841 inclusive, the engines performed an aggregate distance of 850,809 miles, at an aggregate cost of $ 84,183; or within a fraction of 10 cents per mile run. The repairs of cars are fluctuating, but the average is in accordance with the formula. This road is not an exception to the rule, though the formula does not apply for the year 1842.

So long as railroads happened to occupy positions where they would be used for the mere conveyance of the travel, and a few thousand tons of goods, between adjacent cities, the durability of iron was a question of subordinate interest. An engineer could be satisfied that his rail would last 10 or 20, or 30, years, and could generally count on a sufficient increase of business consequent on the increase of population, to compensate for its destruction in that space of time. But railroads are now projected to take the place of important canals, and to furnish the means of transport for the heavy products of the earth at exceeding low rates. The question assumes, therefore, another aspect. The trade of the Erie canal in New York, and of the Schuylkill Navigation in Pennsylvania, may be estimated at 700,000 to 1,000,000 tons per annum; and there is no railroad in the United States worked by steam power, which accommodates more than the one-ninth, or one-tenth, of this amount, with the exception of the Reading railroad, which has not yet been long enough in operation to yield any useful practical results.

The common half-inch flat bar, under ordinary circumstances, is adequate to the transportation of about 150,000 tons of freight. Such a bar on the Petersburg road, where the freight amounts to some 25,000 tons, would resist the wear of six years' business; but if one year's trade of the Schuylkill canal were poured along it, the iron part of the track would need entire renewal *six times in one year*.

The same remark is applicable to any of the same sort of wooden roads in the country. They would all bear about 150,000 tons net, drawn at the usual speed of ordinary freight engines, but would be completely destroyed by about *five weeks' business* of the Schuylkill Navigation, in the season of active trade.

It must be admitted that we have not yet sufficient data for estimating, with entire certainty, the probable durability of many varieties of rails. We have, however, data sufficient, if we use it properly, to make a much nearer approximation than is generally supposed to be practicable. The durability of the half inch plate rail can be determined with all desirable accuracy, and we can judge from analogies, which the problem presents, the probable wear of other patterns. Great errors have been committed in the consideration of this subject, by overlooking the fact that the progress of the wear is rarely ascertained, or, in the least, appreciated, until the rail is destroyed. The annual charge for iron is very small, because, in general, the track does not appear to give way until it is nearly unfit for use. When repairs really commence, the destruction is so far advanced that the iron must be renewed; and if the directors assert, as they usually do, in their next report to the stockholders, that experience has shown that the original iron was very bad, and has all been crushed, the explanation is satisfactory, and the cost of the new iron is forthwith charged to the account of construction.

We accordingly find, in looking through the reports of railroad companies, that the average annual increase of capital, generally exceeds the dividends even of the most successful enterprizes; and *there is not now to be found in the country a single road which has renewed its iron out of the proceeds of transportation.* While the trade continues to be small, and this extraordinary outlay is needed but once every 6 or 8 years, the self-deception can be practiced with considerable success. But there are now works constructed which are intended for a very great business, and which will reduce the extraordinary charge for renewal of iron down to a very ordinary circumstance. The Reading Railroad is contemplated for the conveyance of the present trade of the Schuylkill Canal—from seven to eight hundred thousand—and which will very soon reach one million of tons—and should the experiment succeed, *the cost of iron will be more than equal to the entire renewal of a single track every year.* The question of wear, is, therefore, of immense importance, and can no longer be lightly disposed of by companies of this class.

This, as every other item of railroad expenses, is subject to a certain law, which must be recognized before we can make any effectual progress in our investigation.

The destruction of iron depends on the grades of the road, on the tonnage, and on the travel. Every ton of freight that passes produces a certain amount of injury; every passenger car and every passenger does some injury, and every engine that traverses the line produces its share of mischief; but the number of engines that traverse the road, in conveying a given amount of tonnage, depends on the limiting gradient—and, consequently, the destruction of iron, *cæteris paribus*, is greatest on those roads of which the grades are most unfavorable to the useful effect of the power.

If we call N the number of miles traveled by all the engines on the line; T the number of tons net conveyed one mile; and P the passengers conveyed one mile, for one year, then

$$aN+bT+cP,$$

will be the form of the expression which represents the amount of injury which the iron has sustained—$a$, $b$, and $c$, being constants to be supplied by experiment. It is assumed, of course, that the weight and form of the rail, as well as the weight, construction, and velocity of the engines, are uniform.

The point, now, is to determine the values of the coefficients, $a$, $b$, and $c$. For this purpose I take, in the first place, a road on which engines are not used, and but few passengers are conveyed. The wear of iron on such a road gives us the value of $b$, or the injury done by the tonnage.

There are two works of this description of which we can find published reports, and which have been long enough in activity to destroy a portion, or the whole, of their iron.

The *Chesterfield Railroad*, in Virginia, constructed with a flat bar, and using horse power and light cars, has required, for some years past, about $ 200 per mile for new iron, to replace that which is destroyed by the passage of an average trade of about 50,000 tons of coal. The destruction is here equivalent to *four mills* per ton per mile.

The *Mine Hill and Schuylkill Haven Railroad* was originally constructed with a flat bar, and six miles in length of the road had been renewed with a heavy edge rail, before 400,000 tons had passed along it. Assuming the value of the flat bar at $ 60 per ton, or $ 1200 per mile, which is below its present value, and that the iron was worn out by 400,000 tons, the result will be three mills per ton per mile. But this road is provided with a double track, and the track which was destroyed was not used by the ascending cars.

The injury produced by the empty cars is certainly more than one-third of that effected by those which are loaded; and the result on this road, therefore, corresponds very closely with the previous example. The wear then obviously will not be less than 4 mills on a road sustaining locomotive power—where the velocity is much greater than on the Chesterfield and Mine Hill roads.

I will not, therefore, be above the mark in assuming $b=4$ mills.

The flat bar on the *Petersburg Road* may be considered to have been worn out in six years, by use which was equivalent to 12,000 trips of locomotive engines; 130,000 tons of freight, and 100,000 passengers carried over each mile. If we consider the injury caused by cars carrying 5 passengers, equal to that produced by those carrying 1 ton of freight, and the value of this iron equal to $ 1200 per mile, we shall have

$$b\,\mathrm{P}+c\,\mathrm{T}=\$\,600$$

for the damage due to the freight and passengers.

The remaining sum of $ 600 is the destruction produced by the 12,000 miles run by the locomotive engines; whence we have

$$a=\frac{60.000}{12,000}=5\text{ cents};$$

or 5 cents for the injury done by the passage of the locomotive engine over every mile of the road.

We obtain, then, from this procedure, $a=5$ cents; $b=4$ mills; and $c=\frac{4}{5}$ mill, and for our formula

$$\frac{5\,\mathrm{N}}{100}+\frac{4\,\mathrm{T}}{1000}+\frac{4\,\mathrm{P}}{5000}.$$

If these values be correct they will apply to any other similar case.

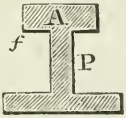
The first iron used on the South Carolina Road, was destroyed in less than six years—after it had borne about 130,000 through tons, and 120,000 through passengers, and the locomotive engines had made 10,000 through trips. The formula will give for this case,

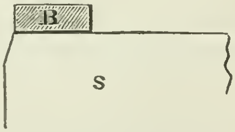
$$\frac{10{,}000 \times 5}{100} + \frac{130{,}000 \times 4}{1000} + \frac{120{,}000 \times \frac{4}{5}}{1000} = \$\,1{,}116$$

for the destruction of the iron per mile. This is, no doubt, very near the true value of the first iron used on that road, estimated at the present prices.

There are several other roads, of both descriptions, for which similar computations might be made, and which would confirm the estimate—and I shall take occasion, at a subsequent period, to present much data of the same character in a tabular form. But without discussing this branch of the subject further, at present, it may be stated in round numbers, that the average destruction of the half inch plate rail, caused by engines, freight, and passengers, is equal to about 8 *mills per ton net per mile;* and by comparing the above expression of the wear of the rail, with that previously obtained for the wear of the cars and engines, we will perceive that they possess very nearly the same value—or that the injury done to this iron, by the passage of a train, is but about 10 per cent. less than the wear and tear of the engine and cars composing the train.

In the application of this formula, however, the fact is not to be overlooked, that it is derived from the destruction of the plate rail, and is intended only to be applied to that description of road. *The destruction of any form of* T *or* H *rail, which I have yet seen, will be greater.* It is true that the expenses of maintenance for some new roads, provided with heavy iron, are yet very light, and they will possibly continue to be light until they have carried from three to five hundred thousand tons of freight—when, if the rail is still in existence, they will be very heavy.





It requires but little experience, and no speculation, to bring us to this conclusion. Let us take the two patterns, fig. 1, and fig. 2, for the purpose of illustration. Fig. 1, is a common form of edge rail, of 60 pounds per yard, of which the head, or upper table, A, weighs 20 pounds. Fig. 2, is a common plate rail, 2½ inches wide, by ⅞ of an inch thick, which also weighs about 20 pounds.

This flat bar is supported along its whole length and breadth by the wooden string, S, and the edge rail is supported only in the centre by the vertical stem, P. Is there now any reason why the unsupported flanch, *f*, should do more service than the supported flat bar, B? The vertical stem and base of fig. 1 never wear out; it is the head of that rail which is crushed and rolled to pieces. When the rail is destroyed the lower portions are untouched; but when the head is bruised and split, the whole rail is rendered useless—and when the rail is ruined, 60 pounds of iron per yard, are lost to the company. The flat bar will bear just as much—indeed, being supported, a little more—hammering, and when it is destroyed, but twenty pounds are lost. Besides it may be welded when broken, the ends may be "upset," and restored when split; new holes, when necessary, may be punched, and it can be returned to the road until the lamination and splintering throughout render it wholly unfit for useful service.

But it is not my intention to speculate here on the relative merits of rails. The present object is to adduce facts and conclusions based on observation of many roads of various descriptions, in relation to the destruction of such rails as are ordinarily adopted. I know that my opinions on this head are not those of the public, nor of many professional gentlemen of much experience; but I believe they are, nevertheless, correct, and I therefore submit them to a test which will speedily be applied, and by which this question will be most conclusively settled.

The rails of the Reading road are, by common consent, acknowledged to be good; the pattern is considered, by the advocates of edge rails, to be unexceptionable; and the mode of manufacture adopted—that of making the lamina horizontal—is considered to render them almost proof against wear.

In regard to these rails—with all their merits, and all their superiority—I affirm,

1st. That they will not withstand the rolling of the trade of the Schuylkill valley for one year.

2nd. That before 800,000 tons of coal have passed down, and the empty cars have been returned on them, the present track will be entirely unfit for safe usage.

3rd. That it will cost from 50 to 75 cents to replace the iron which is destroyed by each ton of coal that descends from Pottsville to Richmond, on the present track. And,

4th. That before next August, if the company succeed in obtaining the trade which they desire, this rail will be pronounced *too light* by the very parties who now think it will last forever.

The fault, however, is less in this particular rail than in *iron*, which is not tough enough for such usage at such prices.

I know that the *Providence road* will be adduced as evidence against me, where the road has been some six years in use, and the iron is yet sound; but the Providence road actually passes but 30,000 tons per annum on a single track, and must yet stand 25 years before it can do one year's business of the Schuylkill canal.

The *Georgia road* may, perhaps, be quoted as evidence, where *experience*, they say, has demonstrated, beyond all question, the ability of railroads to compete with canals, for the conveyance of heavy freight; but the Georgia railroad has been less than three years in operation, and has *not yet carried as much freight as has sometimes passed along the Schuylkill canal in three days.* Pour the trade of the Schuylkill, or Erie, canal, on parts of that road, with such engines as would be needed for its conveyance, and the track would be crushed in less than four weeks.

The *Boston and Lowell road* will be quoted. This road has not yet carried, in the eight years of its existence, an aggregate tonnage equal to the Schuylkill trade—and that tonnage has been sufficient for the destruction of the first track of edge rail, and the company are now, and have been for some time, using the second and third tracks.*

The *Camden and Amboy road* was originally provided with a "permanent" track. The aggregate trade has not yet reached 300,000 tons net—the reader who feels any interest in such matters can cross the Delaware to Camden, and examine the old rails, and form his own conclusions; he will then be able to judge whether these have given out because they are too weak, or because the material, in this form, is inadeqate to a much greater effort.

In *England*, however, it is contended, people have more experience. The *best* experience there, is that of the Liverpool and Manchester Railroad, a work which was opened to public use in the fall of 1830. This road was at first supplied with two tracks of edge rails, weighing 35 pounds per yard. The rail answered very well until the fall of 1833, when the work had passed about 300,000 tons on each track, at which period £150 were expended for *new rails*. In the next half year, before they had transported 350,000 tons, an additional outlay of 3000 pounds sterling was required for new rails, and the adopted pattern was pronounced *too light* for the service. A rail weighing 50 pounds per yard was next tried, and subsequent experience showed that that also was *too light*. A new pattern was then projected, weighing 62 pounds per yard, and forthwith submitted to the same rough usage. The trade on this road is great, and soon tests the merit of a fancy. This pattern was also found inadequate, and another, weighing 70 pounds per yard, was fixed upon, which was, *last year*, regarded as the pattern rail. I have not yet heard how it wears, but one year more will test its strength on that road, where there is really a heavy trade, although the net tonnage does not reach one-half, nor much exceed one-third, of the average trade of the Schuylkill, or Erie, canals. I do not believe that either pattern would resist the action of one year's business of one of those works, if it were confined to a single track.

I trust that those who have made observations on this interesting subject, will communicate them for publication in this journal. If there be an edge rail in the United States, which has sustained the passage of a million of tons of freight,† conveyed by locomotive engines, it could not but be regarded as a most encouraging circumstance, and its history ought to be known; such a rail—weighing 60 pounds per yard—would show the practicability of reducing the average cost of this item for such rails down to 6 mills per ton per mile; and, therefore, below any result which I have yet been able to obtain. My impression is, from the comparisons of the actual destruction which I have been able to make, that its value may be reduced, by the adoption of a suitable flat bar, and a moderate speed, to 3½, or 4, mills per ton per mile.

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* It is proper to say that the rails of this road were taken up after six years' use, because they were too weak; but we never meet with rails that are *strong enough* after they have sustained the passage of 600,000 tons.

† In a report on Herron's cast-iron rails laid before the Committee on Science and the Arts of the Franklin Institute, about two years ago, I stated that no road in the United States had yet sustained one million of tons of freight: I have not yet heard of such an instance.

(To be continued.)

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## *Experiments on Water-Wheels, having a vertical axis, called Turbines.* By Arthur Morin, C. A., P. M. S. A., &c. &c.

(Translated from the French, by Ellwood Morris, Civil Engineer.)

[Continued from Page 302.]

### XXV.

### *Observations on the emission of the water by the openings of the Turbine.*

It remains for us to make known some results of particular observations on the mode of gauging adopted at Müllbach, for estimating the expenditure of water made during the experiments.

Our design in uniting these results was to know if it were possible to determine, for each lift of the sluice-gate, the value of the coefficient of the discharge made by the openings of the turbine, in order to be able to calculate directly the volume of water vented by these orifices, in cases where it would not be possible to establish direct modes of gauging; but we must, nevertheless, premise, that not having been able to give to the means of observation sufficient precision, we have not pretended to arrive at results, comparable for exactness, with those which have been obtained either at Metz, or Toulouse, and that we solely propose to establish the approximate values, and to examine the influence of the velocity of the wheel, and of the size of the openings. Knowing, for each experiment, the volume of water discharged, the lift of the sluice-gate, the sum of the horizontal breadths of the orifices, or the shortest distances between the curved guides of the sluices, equal to (1.56 m.) 5 $\frac{12}{100}$ feet, we have compared the theoretical expense, made under the known difference of the upper and lower levels, to the effective expense, (or actual discharge of water,) and we have by it deduced the corresponding value of the coefficient of the discharge; [or that constant number, which, multiplied by the known areas of the openings, and by the theoretical velocity of the water due to the fall, gives the actual discharge.—Tr.]

The results of this comparison are recorded in the following table, which shows at once that the coefficient increases with the velocity of the wheel; this is a consequence of the action of the centrifugal force diminishing the pressure exerted below in the orifices, and tends consequently, to augment the discharge; but as the immediate results of the experiments do not offer all the regularity desirable for observations on the emission of the water, we have sought another way to unite them, and by it to deduce a kind of general law, by representing them by the curves, Figs. 9, 10, 11, 12, and 13, Plate II, of which the abscisses are the number of turns of the wheel in a minute, and the ordinates the coefficients of the discharge deduced from calculation.

*Observations on the emission of water by the sluices of the Turbine of Müllbach = outer diameter 2 metres, inner diameter about* 1.6 *metre ; circumference, inner circle* = 5.024 *metres.*

| Number of the experiments. | Sum of the areas of the orifices. | Lift of the sluice-gate of the turbine. | Charge of water, or difference of the levels, above and below. | Number of turns of the wheel in one minute. | Discharge of water in a second. | | Coefficient of the discharge. | Theoretical velocity of the water per second. | Velocity of the wheel at the inner circle, per second. | Ratio of the velocity of the wheel at the inner circle, to the theoretical velocity of the water per second. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Theoretical. | Actual. | | | | |
| | Sq. m. | Metres. | Mtrs. | No. | M. cub. | M. cub. | | Metres. | Metres. | |
| 1 | 0.078 | 0.050 | 3.552 | 72. | 0.650 | 0.623 | 0.957 | 8.35 | 6.02 | 0.721 |
| 2 | " | or | 3.547 | 67.9 | 0.650 | 0.628 | 0.957 | 8.35 | 5.68 | .680 |
| 3 | " | .050 | 3.560 | 64.8 | 0.651 | 0.623 | 0.956 | 8.36 | 5.42 | .648 |
| 4 | " | .330 | 3.580 | 63.1 | 0.654 | 0.623 | 0.953 | 8.38 | 5.28 | .630 |
| 5 | " | 10-66ths | 3.580 | 60.0 | 0.654 | 0.523 | 0.953 | 8.38 | 5.02 | .600 |
| 6 | " | of whole | 3.565 | 57.6 | 0.651 | 0.623 | 0.956 | 8.36 | 4.82 | .577 |
| 7 | " | height | 3.555 | 55.3 | 0.650 | 0.611 | 0.940 | 8.35 | 4.63 | .554 |
| 8 | " | 0.333 m. or | 3.565 | 53.3 | 0.651 | 0.611 | 0.938 | 8.36 | 4.46 | .533 |
| 9 | " | 15-100ths | 3.580 | 50.7 | 0.654 | 0.611 | 0.935 | 8.38 | 4.24 | .506 |
| 10 | " | of 0.333 m. | 3.585 | 47.6 | 0.654 | 0.610 | 0.933 | 8.38 | 3.94 | .470 |
| 11 | " | or 1-100th | 3.621 | 43.9 | 0.657 | 0.610 | 0.930 | 8.43 | 3.67 | .435 |
| 12 | " | of the cir- | 3.621 | 40.9 | 0.657 | 0.610 | 0.930 | 8.43 | 3.42 | .406 |
| 13 | " | cumfer'ce | 3.650 | 37.5 | 0.660 | 0.610 | 0.925 | 8.46 | 3.14 | .371 |
| 14 | " | of inner | 3.680 | 34.25 | 0.661 | 0.610 | 0.923 | 8.50 | 2.86 | .327 |
| 15 | " | circle. | 3.703 | 31. | 0.665 | 0.623 | 0.935 | 8.52 | 2.59 | .303 |
| 16 | " | | 3.725 | 28.1 | 0.666 | 0.623 | 0.933 | 8.54 | 2.35 | .275 |
| 17 | " | | 3.730 | 26.85 | 0.667 | 0.623 | 0.931 | 8.55 | 2.24 | .262 |
| 18 | " | | 3.750 | 21.7 | 0.668 | 0.623 | 0.935 | 8.58 | 1.82 | .212 |
| 19 | 0.1404 | 0.090 | 3.224 | 75. | 1.112 | 1.156 | 1.039 | 7.95 | 6.28 | .790 |
| 20 | " | or | 3.199 | 69. | 1.109 | 1.087 | 0.990 | 7.93 | 5.77 | .729 |
| 21 | " | .09 | 3.208 | 65. | 1.110 | 1.101 | 0.993 | 7.93 | 5.45 | .687 |
| 22 | " | .333 | 3.210 | 61.6 | 1.110 | 1.071 | 0.996 | 7.94 | 5.15 | .649 |
| 23 | " | 27-100ths | 3.196 | 59.2 | 1.109 | 1.071 | 0.965 | 7.93 | 4.96 | .625 |
| 24 | " | of whole | 3.177 | 56. | 1.105 | 1.071 | 0.972 | 7.90 | 4.69 | .594 |
| 25 | " | height | 3.190 | 52. | 1.109 | 1.036 | 0.936 | 7.91 | 4.35 | .550 |
| 26 | " | 0.333, or | 3.190 | 49.2 | 1.109 | 1.016 | 0.917 | 7.91 | 4.12 | .521 |
| 27 | " | 18-100ths | 3.207 | 45.25 | 1.119 | 1.016 | 0.916 | 7.94 | 3.79 | .477 |
| 28 | " | of circumf. | 3.207 | 41. | 1.110 | 1.016 | 0.916 | 7.94 | 3.43 | .432 |
| 29 | " | of inner | 3.213 | 37.2 | 1.110 | 1.008 | 0.908 | 7.94 | 3.11 | .392 |
| 30 | " | circle, or | 3.225 | 35. | 1.112 | 1.008 | 0.906 | 7.95 | 2.93 | .369 |
| 31 | " | 27-100ths | 3.265 | 32.5 | 1.120 | 0.971 | 0.869 | 8.00 | 2.72 | .340 |
| 32 | " | of whole | 3.305 | 29.5 | 1.177 | 0.971 | 0.827 | 8.05 | 2.47 | .307 |
| 33 | " | height. | 3.295 | 27.5 | 1.175 | 0.976 | 0.831 | 8.04 | 2.30 | .286 |
| 34 | 0.2340 | 0.150 | 3.164 | 99.5 | 1.840 | 1.881 | 1.022 | 7.88 | 8.33 | 1.057 |
| 35 | " | or | 3.164 | 92.0 | 1.840 | 1.786 | 0.972 | 7.88 | 7.70 | .977 |
| 36 | " | 45-100ths | 3.150 | 90.0 | 1.839 | 1.781 | 0.960 | 7.86 | 7.54 | .959 |
| 37 | " | of whole | 3.153 | 83.5 | 1.839 | 1.751 | 0.954 | 7.86 | 6.99 | .890 |
| 38 | " | height; | 3.110 | 78.5 | 1.825 | 1.747 | 0.957 | 7.81 | 6.57 | .841 |
| 39 | " | | 3.070 | 73.0 | 1.815 | 1.766 | 0.974 | 7.76 | 6.11 | .787 |
| 40 | " | | 3.070 | 69.0 | 1.815 | 1.666 | 0.917 | 7.76 | 5.77 | .744 |
| 41 | " | | 3.075 | 63.0 | 1.815 | 1.641 | 0.905 | 7.76 | 5.27 | .679 |

## *Observations, &c.—Continued.*

| No. of the experiments. | Sum of the areas of the orifices. | Lift of the sluice-gate of the turbine. | Charge of water, or difference of the levels, above and below. | Number of turns of the wheel in one minute. | Discharge of water in a second. | | Coefficient of the discharge. | Theoretical velocity of the water per second. | Velocity of the wheel at the inner circle per second. | Ratio of the velocity of the wheel at the inner circle, to the theoretical velocity of the water, per second. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Theoretical. | Actual. | | | | |
| | Sq.Mt. | Metres. | Mtrs. | No. | M. cub. | M. sub. | | Metres. | Metres. | |
| 42 | 0.2340 | 0.150 | 3.035 | 58.25 | 1.800 | 1.586 | 0.883 | 7.71 | 4.87 | .631 |
| 43 | " | or | 3.085 | 52.0 | 1.820 | 1.576 | 0.867 | 7.78 | 4.35 | .559 |
| 44 | " | 30-1000ths | 3·085 | 48.0 | 1.820 | 1.561 | 0.859 | 7.78 | 4.02 | .517 |
| 45 | " | of the cir- | 3.085 | 44.0 | 1.820 | 1.526 | 0.840 | 7.78 | 3.68 | .473 |
| 46 | " | cumference | 3.380 | 45.3 | 1.900 | 1.652 | 0.872 | 8.14 | 3.79 | .466 |
| 47 | " | of the inner | 3.272 | 38.0 | 1.873 | 1.528 | 0.817 | 8 01 | 3.18 | .397 |
| 48 | " | circle. | 3.400 | 38 5 | 1.909 | 1.528 | 0.801 | 8.17 | 3.22 | .394 |
| 49 | " | | 3.405 | 34.4 | 1.909 | 1.528 | 0.798 | 8.17 | 2 88 | .353 |
| 50 | 0.3120 | 0.200 | 3.020 | 104. | 2.402 | 2.053 | 0.854 | 7.70 | 8.70 | 1.130 |
| 51 | " | or 60-100ths | 3.045 | 103. | 2.404 | 2.033 | 0.860 | 7.73 | 8.62 | 1.115 |
| 52 | " | of the whole | 3.080 | 101.5 | 2.422 | 2.025 | 0.847 | 7.77 | 8.49 | 1.092 |
| 53 | " | height, or | 3.120 | 95 | 2.443 | 2.003 | 0.822 | 7.83 | 7.95 | 1.015 |
| 54 | " | 40-1000ths | 3.170 | 90.4 | 2.464 | 1.993 | 0.809 | 7.89 | 7.57 | .959 |
| 55 | " | of circum- | 3.190 | 87.1 | 2.470 | 1.951 | 0.807 | 7.91 | 7.29 | .921 |
| 56 | " | ference of | 3.203 | 82.8 | 2.472 | 1.913 | 0.766 | 7.93 | 6.93 | .874 |
| 57 | " | the inner | 3.240 | 80. | 2.490 | 1.913 | 0.768 | 7.97 | 6.70 | .841 |
| 58 | " | circle. | 3.255 | 75. | 2.491 | 1.913 | 0.768 | 7.99 | 6.28 | .786 |
| 59 | " | | 3.270 | 70. | 2.500 | 1.913 | 0.767 | 8.01 | 5.86 | .731 |
| 60 | " | | 3.305 | 67.6 | 2.509 | 1.913 | 0.765 | 8·05 | 5.66 | .703 |
| 61 | " | | 3.310 | 67.1 | 2.512 | 1.913 | 0.759 | 8.06 | 5.62 | .697 |
| 62 | " | | 3.310 | 63. | 2.512 | 1.872 | 0.747 | 8.06 | 5.27 | .654 |
| 63 | " | | 3.335 | 58. | 2.522 | 1.872 | 0.742 | 8.09 | 4.86 | .601 |
| 64 | " | | 3.306 | 50.6 | 2.509 | 1.812 | 0.722 | 8.06 | 4.24 | .526 |
| 65 | " | | 3.286 | 48.5 | 2.502 | 1.812 | 0.724 | 8.03 | 4.06 | .505 |
| 66 | " | | 3.321 | 44. | 2.520 | 1.812 | 0.720 | 8.07 | 3.68 | .456 |
| 67 | " | | 3.610 | 100. | 2.622 | 2.173 | 0.829 | 8.42 | 8.27 | .994 |
| 68 | " | | 3.650 | 97. | 2.642 | 2.082 | 0.790 | 8.46 | 8.12 | .960 |
| 69 | " | | 8.560 | 91. | 2.607 | 2.143 | 0.805 | 8.36 | 7.62 | .912 |
| 70 | " | | 3.475 | 87. | 2.570 | 2.083 | 0.815 | 8.25 | 7.28 | .882 |
| 71 | " | | 3.300 | 80. | 2.620 | 2.061 | 0.788 | 8.04 | 6.69 | .832 |
| 72 | " | | 3.250 | 72. | 2 493 | 1.983 | 0.796 | 7.99 | 6.03 | .755 |
| 73 | " | | 3.230 | 67. | 2.483 | 1.943 | 0.782 | 7.96 | 5.61 | .706 |
| 74 | " | | 3.358 | 62.1 | 2.715 | 1.933 | 0.710 | 8.11 | 5.19 | .640 |
| 75 | " | | 3 343 | 57.1 | 2.710 | 1.908 | 0.702 | 8.10 | 4.78 | .590 |
| 76 | " | | 3.393 | 54. | 2.548 | 1.863 | 0.733 | 8.15 | 4.52 | .554 |
| 77 | " | | 3.398 | 49.4 | 2.542 | 1.863 | 0.733 | 8.16 | 4.12 | .505 |
| 78 | 0.4212 | 0.270 | 2.990 | 90.6 | 3.230 | 2.523 | 0.782 | 7.66 | 7.58 | .989 |
| 79 | " | or 81-100ths | 3.070 | 87. | 3.207 | 2.523 | 0.773 | 7.76 | 7.28 | .938 |
| 80 | " | of the whole | 3.170 | 84.6 | 3.320 | 2.442 | 0.737 | 7.89 | 7.08 | .897 |
| 81 | " | height, or | 3.180 | 77.25 | 3.240 | 2.442 | 0.757 | 7.90 | 6.47 | .819 |
| 82 | " | 54-1000ths | 3.310 | 69. | 3.540 | 2.442 | 0.691 | 8.06 | 5.77 | .716 |
| 83 | " | of circum. of | 3.475 | 66.1 | 3.470 | 2.523 | 0.730 | 8.25 | 5.54 | .671 |
| 84 | " | inner circle. | 3.390 | 61.5 | 3.430 | 2.445 | 0.712 | 8.16 | 5.14 | .630 |

[Note.—The three last columns of this table have been added by approximation, so as to show, nearly, the relative velocities of the wheel at the inner circle, and that which theory assigns to the water under the several falls stated.—Tr.]

## XXVI.

### *Consequences of the results contained in the preceding table.*

This table, or rather an examination of the foregoing curves, figs. 9 to 13, shows:—

1. That for the small lift of sluice-gate of (0.050 m.) $\frac{16}{100}$ of a foot, the coefficient of the discharge, or which comes to the same, the expense of water made in a second, by the orifices of the turbine, increased a little, with the velocity of the wheel, but so slowly that its mean value, from 20 unto 55 turns in a minute, is equal to about 0.93, and that it rises gradually with the velocity up to the value 0.96, when it reaches about 65 turns in a minute.

2. That at a lift of sluice-gate of (0.09 m.) $\frac{29}{100}$ of a foot, the coefficient of the discharge, which is about 0.93, at the velocity of 25 turns in a minute, rises very rapidly with the velocity, and reaches with about 75 turns in a minute the value 1.039, which shows that the effective discharge will be greater than the theoretical discharge.

3. That at a lift of sluice-gate of (0.150 m.) $\frac{49}{100}$ of a foot, this coefficient, which had only the value of 0.80, at the velocity of 34 turns in a minute, reached, and also exceeded that of *unity*, at the velocity of 99½ turns in a minute.

4. That at a lift of sluice-gate of (0.200 m.) $\frac{65}{100}$ of a foot, this coefficient, which had only the value of 0.72, at the velocity of 45 turns in a minute, reached that of 0.85, at the velocity of 102 turns in a minute.

5. Finally, that at a lift of the sluice-gate of (0.270 m.) $\frac{88}{100}$ of a foot, the same coefficient which had the value of 0.71 at the velocity of 75 turns in a minute, reached that of 0.76 at the velocity of 106 turns in a minute.

From these it results evidently that the discharge of water made by the turbines, increases with their velocity of rotation, and, moreover, as the effect of the centrifugal force to which this increase is due, depends on the proportions of the wheel, it follows that we shall be able to establish, in each case, a discussion of these proportions, by comparing the effects to the cause.

## XXVII.

### *Influence of the height of the Lift of the Sluice-gate on the discharge.*

The curves of the coefficients show us also that these numbers, at equal velocities, are incessantly diminishing in proportion as the lift of the sluice-gate increases. We can verify this by examining the following table, in which we have combined the relative values at the different velocities and lifts of the sluice-gate, deduced from the mean trace of these curves.

| No. of turns of the wheel per minute. | Value of the coefficients of the discharge, for the following lifts of sluice-gate. | | | |
|---|---|---|---|---|
| | 0.090 m. | 0.150 m. | 0.200 m. | 0.270 m. |
| 40 | 0.905 | 0.820 | | |
| 50 | 0.945 | 0.862 | 0.728 | |
| 60 | 0.975 | 0.900 | 0.743 | |
| 70 | 0.995 | 0.930 | 0.762 | 0.706 |
| 80 | | 0.953 | 0.784 | 0.720 |
| 90 | | 0.968 | 0.812 | 0.746 |
| 100 | | 0.980 | 0.840 | 0.767 |

[Note.—We have not comprised in this table the coefficients relative to a lift of the sluice-gate of 0.050 m., because under the ratio sought, it did not admit of showing the diminution which is here the question.]

This diminution of the coefficient of the expense of water, in proportion as the lift of the sluice-gate augments, belongs evidently to the disposition of the orifices, and seems to us easy to explain, from the facts known of the emission of water by ajutages of many forms.

In effect, from the manner in which the orifice is disposed, the two contiguous curves forming the vertical walls give it, in this sense, a form analogous to that of casks, where the ajutages converge; the lower side is found in the prolongation of the bottom, and the upper side is the lower one of the cushion of wood that rises with the sluice-gate. It follows that for small lifts of sluice-gate the water issues by a true ajutage conic laterally, and with faces parallel on the vertical sides, and for which the contraction, at the entrance, is nearly null. It is not then astonishing that in that case the coefficient of the discharge attains a value equal, and even superior, to 0.90, since we know (Traité d'Hydraulique de M. d'Abuisson, p. 54,) that for conic converging ajutages, this number acquires, according to the inclination of the sides of the cone, similar values.

In proportion as the lift augments, the influence of the cushion for diminishing the contraction of the entrance of the ajutage, becomes less, because in spite of the rounding of its lower border, it has not the exact form of the fluid vein, and as the volume of water expended augments, the velocity in the interior pipe becomes greater, in consequence of the convergence of the fillets near the orifice.

The cushion has, moreover, only (0.170 m.) $\frac{56}{100}$ of a foot mean thickness in the direction of the length of the ajutage, and when the lift of the sluice-gate reaches, or exceeds, (0.150 m.) $\frac{49}{100}$ of a foot, we see that this ajutage approaches, in advantage, to those which have contraction at the entrance, or of the orifices with contraction on the upper side solely.

The change of direction that the water suffers in descending the vertical pipe, to issue parallel to the bottom, occasions also a loss of active force, which ought to increase with the lift of the sluice-gate.

All these circumstances which concur to the same results, sufficiently explain, I think, the gradual diminution of the coefficients, and, as we have seen before, that this number, on the contrary, augments with the velocity of rotation, and that these two variations in opposite directions, depend upon the proportions of the wheel, we see that, in all experiments, or observations, on wheels of this species, it is indispensable to establish, for gauging the water expended, a stop-gate *above*, or better yet, *below* the wheel. It will be, moreover, always preferable to establish it below, because, on the one hand, the variations of level occasion much less error, and above all, less loss of time in regulating the level, and which we are able to appreciate, as we had to take at Müllbach, the volumes of water produced by the leakage, more or less great, of the reservoirs, and of the sluices.

We ought to remark that the experiments on the turbine of Moussay, have also shown that the coefficient of the discharge, diminished in proportion as the lift of the sluice-gate augmented, but that the increase produced by the centrifugal force, during the great velocities, did not there manifest itself in a notable manner; owing, perhaps, to this, that the wheel, having only a very little breadth, the action of this force there was much less sensible.

## XXVIII.

### *Experiments on the Turbine established in the Mill of Lepine, Canton of Arpajon.*

The account rendered of the session of the (French) Academy of Sciences of the 5th February, 1838, contains a series of experiments made by M. Dieu, Chief of Squadron of Artillery, and Inspector of the Gunpowder Manufactory of the Bouchet. We, from it, insert the results:

The gauge of the expense of water was made by means of a stop-gate placed *above* the wheel in the canal of supply, and forming a waste-board; and we have calculated the volume of water emitted by the formula,

$$Q = 0.406\, LH \sqrt{2gH}.$$

Floats placed above this waste-board, and above and below the turbine, served to measure the charge of water on the sill of the waste-board, and the total fall.

The *brake* was formed of a cast-iron muff, or collar, embraced by two pieces of wood which were placed on the shaft of the wheel, and continually wetted by a fillet of water which prevented the overheating of the surfaces, and kept them at a constant state of humidity. The other dispositions were also entirely analogous to those which we have before detailed.

The arm of the lever of the brake was (4 metres) $13\frac{12}{100}$ feet long, and the constant load was (0.625 kilogrammes) $1\frac{35}{100}$ pounds.

The results of the experiments are recorded in the following tables:

*Experiments on the Turbine of Lepine, near Arpajon, (Department of Seine-et-Oise.)*

| Nos. of the experiments. | Volume of water discharged in a second. | Total fall. | Theoret. Power of the motor. | | Total load of the brake. | No. of turns of the wheel in a minute. | Useful effect measured by the brake. | | Ratio of the useful effect to the theoretical power of the motor. |
|---|---|---|---|---|---|---|---|---|---|
| | | | No. kilog. lifted one metre per second. | No. horses-power. | | | No. of kilogs. lifted one metre in a second. | No. of horses-power. | |
| | M. cub. | Mtrs. | Kilog. | Hrs. pr. | Kilog. | No. | Kilog. | Hrs. pr. | |
| 1 | 0.436 | 2.073 | 904.0 | 12.05 | 22.625 | 73.77 | 699.0 | 9.32 | 0.773 |
| 2 | 0.440 | 2.048 | 901.6 | 12.01 | 18.625 | 88.20 | 688.2 | 9.17 | 0.763 |
| 3 | 0.440 | 2.065 | 908.6 | 12.11 | 20.625 | 80.35 | 694.0 | 9.25 | 0.763 |
| 4 | 0.440 | 2.065 | 908.6 | 12.11 | 22.625 | 72.58 | 687.7 | 9.17 | 0.757 |
| 5 | 0.440 | 2.048 | 901.0 | 12.01 | 24.625 | 67.16 | 692.7 | 9.23 | 0.768 |
| 6 | 0.440 | 2.043 | 898.9 | 11.98 | 26.625 | 64.10 | 714.8 | 9.53 | 0.795 |
| 7 | 0.436 | 2.048 | 892.9 | 11.90 | 28.625 | 58.44 | 700.6 | 9.34 | 0.784 |
| 8 | 0.436 | 1.993 | 868.9 | 11.59 | 17.625 | 90.90 | 671.0 | 8.94 | 0.772 |
| | 3.508 | 16.383 | 7184.5 | 95.76 | 182.000 | 595.50 | 5448.0 | 73.95 | 6.175 |
| Means. | 0.438 | 2.048 | 898.0 | 11.97 | 22.75 | 74.44 | 681.0 | 9.24 | 0.772 |

The examination of this table shows that this turbine, of which the fall at the time of making these experiments, was about (2 metres) $6\frac{56}{100}$ feet, realized a net useful effect equal to 0.772 of the theoretical power expended by the motor.

## XXIX.

### *General Summary of the Experiments on the Useful Effect of Turbines.*

From the whole of the experiments contained in this memoir, and of those which had before been made relative—

*To the Turbine of Moussay*, where the height of the fall has been, during the experiments, about (7.50 m.) $24\frac{61}{100}$ feet, and where the wheel has been immersed under water about (0.974 m.) $3\frac{19}{100}$ feet.

*To the Turbine of Müllbach*, where the height of the fall has been, during the experiments, about (3.50 m.) $11\frac{48}{100}$ feet, and which has been immersed under water about (0.750 m.) $2\frac{46}{100}$ feet.

*To the Turbine of Lepine*, where the height of the fall is (2 m.) $6\frac{56}{100}$ feet.

*To the Turbine of Inval*,* where the height of the available fall has been successively reduced from (1.174 m. to 0.293 m.) $3\frac{85}{100}$ feet to $\frac{96}{100}$ of a foot, whilst, on the contrary, the depth to which the wheel was immersed, has been augmented from (1.15 m. to 1.74 m.) $3\frac{77}{100}$ feet to $5\frac{71}{100}$ feet.

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* See the Compte Rendus des Seances de l'Academie des Sciences, No. 9, 27th February, 1837.

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Fig. 7.

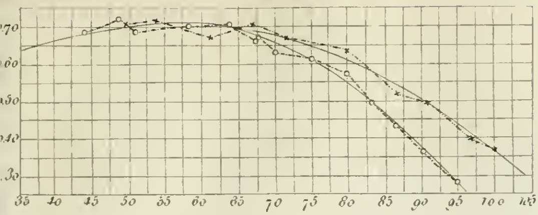


Fig. 8.

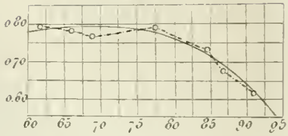


Fig. 9.

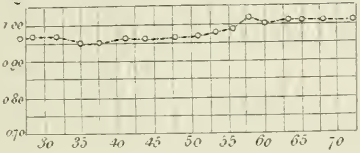


Fig. 10.

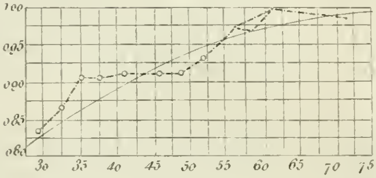


Fig. 11.

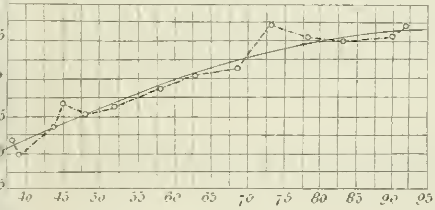


Fig. 13.

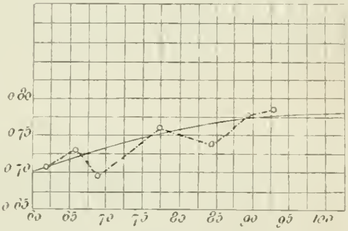
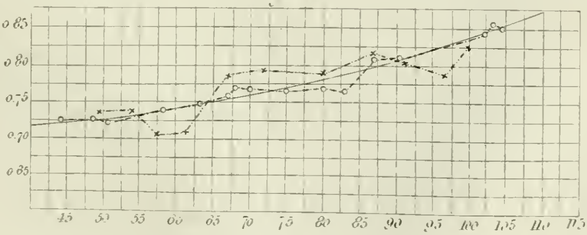


Fig. 12.



Finally, from results obtained at the spinning factory at St. Blaise, in the Black Forest, where they used a fall of (108 m.) $354\frac{35}{100}$ feet! *with a turbine of* (0.55 m.) $1\frac{80}{100}$ *feet diameter, making* 2300 *turns in a minute! and transmitting a power of* 40 *horses!*

We are able to conclude:—

1. *That these wheels are equally suitable to the greatest, as to the smallest, falls.*

2. *That they transmit a net useful effect equal to* 0.70, *or* 0.78, *of the theoretical power expended by the motor.*

3. *That they are able to move at velocities extremely distant, more or less, from that which belongs to the maximum effect, without the useful effect differing notably from this maximum.*

4. *That they are able to do duty under water at depths from* (1 *to* 2*m.)* $3\frac{28}{100}$ *to* $6\frac{56}{100}$ *feet, without the ratio of the useful effect to the theoretical power of the motor, diminishing notably.*

5. *That as a consequence of the preceding property, they use all the time the whole available fall, since we place them below the level of the lowest waters.*

6. *That they are able to receive very variable quantities of water without the ratio of effect to power expended, diminishing notably.*

If we unite to these valuable mechanical properties, the advantage that they offer of occupying but little space, of being able, without any great expense, and without embarrassment, to be established in such part of the works as we wish, of moving generally at velocities much superior to those of other wheels, thus avoiding recourse to the transmission of complicated motions, *we conclude (without doubt with us) that these wheels ought to take rank amongst the best hydraulic motors.*

## *Experiments on the useful effect of Turbines in the United States.*

By Ellwood Morris, Civil Engineer.

The above series of experiments on turbines, made by Morin, corroborated by other experimenters, and finally sanctioned by the approbation of the Academy of France—after undergoing the scrutiny of a special committee of their body deputed for that purpose—are beyond the reach of cavil, and must carry a conviction of the value of these hydraulic motors home to the minds of all who are capable of appreciating subjects of this nature.

Nevertheless, when the writer, some time ago, formed the resolution to attempt the introduction of these valuable water-wheels into use in our country, and entered into a business arrangement with Merrick & Towne, the well known machinists of Philadelphia, for that purpose, they were met at the threshold of their enterprize by an unusual degree of scepticism, which, unfortunately, received here, as in France, a slender resting point from the abortive efforts to construct successful turbines, which were made by some not sufficiently acquainted with the principles of these motors, whose attention had been drawn to them by the articles upon turbines, published, by the writer, in this journal, during the autumn of last year.

It consequence, it seemed in some degree, incumbent on the writer, who had publicly declared the value of these motors, to demonstrate the apparent truism, that with properly constructed turbines, acting under a given quantity and fall of water, the economical results are the same in America as in France.

With this object in view, the writer has carefully tested the only two turbines made by Merrick & Towne, from his drawings, which have yet been put in action.

The first of these was set to work upon the 1st of January, 1843, at the Rockland Cotton Mills, upon the Brandywine stream, and has been running ever since with perfect success, and to the entire satisfaction of the proprietors.

It has continued to run, and drive the cotton mill at full speed, when the fall was reduced one-half by backwater, and when a large breast water-wheel, actuated by the same head race, was unable to turn for days together.

The experiments made upon this turbine, in the presence, and with the aid of the Messrs. Young, of Rockland, were communicated, by the writer, to the American Philosophical Society, on the 30th of May last, at the celebration of their hundredth anniversary, and will be found recorded in their published proceedings, whence the following is extracted:

"The experiments made in France, with the brake of M. Prony, have established, that the coefficient of effect of turbines, or the ratio of power actually realized, to that expended, *is, at an average, seventy per cent.* Mr. Morris has recently tested this result at the Rockland Mills, in Delaware, where the turbine is employed to drive a cotton mill: his experiments are collated in the table which closes this abstract.

"From these tabulated experiments it will appear that with lifts of sluice-gate, ranging from 5 to 7 inches, or from $\frac{5}{8}$ to $\frac{7}{8}$ of the full height of the turbine, and with velocities, at the inner circle, varying from about $\frac{9}{10}$ to near $\frac{5}{10}$ of the theoretical velocity, due to the working fall of water, this motor realized an useful effect, varying from 64 to 70 per cent. of the absolute power expended, or of that which is theoretically due to the expenditure of water, and the available fall at the time.

"The maximum effect seems to have been derived when the lift of the sluice-gate equalled 6 inches, or two-thirds, of the full height of the wheel; and when the turbine, at its inner circle, ran at a speed equivalent to 46 per cent. of the theoretical velocity of the water, issuing, under a head, equal to the working fall.

"An examination of the experiments from the 6th to the 14th inclusive, will show that the coefficients of effect within these limits, notwithstanding considerable variations in the relative velocities of the wheel, and its impelling water, averaged 67 per cent.; thus showing that this turbine, when run with a strong lift of sluice-gate, realized as high a coefficient of effect, as was assigned by Smeaton to overshot water-wheels.

"With regard to the following table, Mr. M. remarked that the quantity of water used, which fixes the theoretical power due to the expenditure and descent, was determined by applying to the openings of the directing sluices certain coefficients of discharge, deduced from those of Morin, on the turbine of Müllbach, by a comparison of the velocities and lifts of gate in the one, and the other case: the results, therefore, are merely proximative, but cannot be very distant from the truth.

"The total fall of water at the Rockland Mills is usually about 7 feet; but the turbine has continued to drive the machinery of the mill effectively when the difference of level was reduced by backwater to three feet three inches, and the wheel was entirely submerged to the depth of four feet. With an external diameter of $4\frac{2}{3}$ feet, and a vertical thickness of about 8 inches, it propels the same machinery which heretofore required two breast wheels, one of 14 feet bucket, and 10 feet diameter, the other of 8 feet bucket, and 16 feet diameter, and uses one-third less water than the latter of these alone.

"Mr. Morris next adverted to the durability of the turbine; he supposes it less liable to wear at the pivot than the common water-wheel; as the latter while running supports a heavy load of water, from which the turbine is relieved by the interior fixed disc, which carries the directing sluices. In the turbine at Rockland, the pivot is ingeniously lubricated with oil by a syphon wick, the oil passing through an opening in the centre of the vertical shaft; after five months' use, the wear of the pivot is not perceptible." *

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* At the time these pages are passing through the press, this turbine has been running eleven months, and no indications of wear are yet displayed by the pivot. We may, therefore, conclude, that no apprehensions need be entertained concerning the wear of the pivots of such turbines as are lubricated in this manner.

*Experiments upon the Turbine at the Rockland Mills, near Wilmington, Del., made by Ellwood Morris, C. E.,* *January 21st,* 1843.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of the experiments. | Vertical lift of the annular sluice-gate in inches. | Aggregate area of the fixed disc open'gs exposed by the sluice-gate in sup. feet. | Proximate coefficients of discharge of the fixed disc openings. | Depression of the water surface in the head and tail races below a fixed level. | | Working fall during the experiments. | Theoretical velocity of water due to the working fall in feet per second. | Proximate quantity of water discharged by the Turbine in cubic feet per minute. | Theoretical power in horses power of 33,000 lbs. lifted one foot high per minute. | Useful effect produced by the turbine as actually measured by the brake dynamometer of M, De Prony. | | | Ratio of the speed of the wheel at the inner circle, to the theoretical velocity of the water due the working fall. | Approximate coefficient of effect, or ratio, of the power actually realized, to the theoretical power. |
| | | | | In head race. | In tail race. | | | | | No. of turns of the wheel per minute. | Load of brake at the end of a radius of 11 feet. | Horses' power developed of 33,000 lbs. lifted 1 foot high per min. | | |
| 1 | 1 | 0.344 | .930 | 3,083 | 9,937 | 6.854 | 20.9 | 401 | 5.2 | 38 | 14 | 1.1 | .317 | .211 |
| 2 | 2 | 0.687 | .923 | 3.083 | 9.625 | 6.542 | 20.5 | 779 | 9.6 | 58 | 28 | 3.4 | .500 | .354 |
| 3 | 3 | 1.031 | .918 | 3.125 | 9.479 | 6.354 | 20.2 | 1146 | 13.8 | 72 | 42 | 6.3 | .621 | .456 |
| 4 | 4 | 1.375 | .830 | 3.188 | 9.271 | 6.083 | 19.8 | 1355 | 15.2 | 74 | 56 | 8.6 | .652 | .566 |
| 5 | 4 | 1.375 | | | | | | | | 59 | 70 | 8.6 | | |
| 6 | 5 | 1.719 | .724 | 3.125 | 9.187 | 6.062 | 19.7 | 1471 | 17 | 57 | 98 | 11.7 | .505 | .688 |
| 7 | 5 | 1.719 | .742 | 3 125 | 9.187 | 6.062 | 19.7 | 1507 | 17.3 | 67 | 74 | 11.8 | .593 | .682 |
| 8 | 6 | 2.062 | .720 | 3,229 | 9.208 | 5 979 | 19.6 | 1745 | 19.8 | 64 | 98 | 13.1 | .565 | .662 |
| 9 | 6 | 2.062 | .720 | 3.229 | 9.208 | 5.979 | 19.6 | 1745 | 19.8 | 59 | 108 | 13.3 | .525 | .672 |
| 10 | 6 | 2.062 | .700 | 3.188 | 9.125 | 5.937 | 19.5 | 1688 | 19 | 46 | 136 | 13.1 | .411 | .690 |
| 11 | 6 | 2.062 | .700 | 3.188 | 9.125 | 5.937 | 19.5 | 1688 | 19 | 52 | 122 | 13.3 | .465 | .700 |
| 12 | 7 | 2.406 | .700 | 3.125 | 9.042 | 5.917 | 19.4 | 1960 | 22 | 49½ | 136 | 14.1 | .445 | .641 |
| 13 | 7 | 2.406 | .700 | 3.104 | 8.958 | 5.854 | 19.3 | 1950 | 21.6 | 56½ | 122 | 14.4 | .510 | .667 |
| 14 | 7 | 2.406 | .700 | 3.146 | 8.958 | 5.812 | 19.3 | 1950 | 21.1 | 60 | 115 | 14.4 | .542 | .683 |

Since these experiments were communicated to the Philosophical Society, the second turbine has been put in operation at the powder works of the Messrs. Dupont, in Delaware.

The writer availed himself here of the liberality and aid of Alfred Dupont, Esq., (whose extensive experience in the use of water power is well known,) to make a series of trials with this motor, in which the amount of water used by the turbine, inclusive of a small leakage from the fore-bay, was measured in two ways:—

1. By causing it to pass through the rectangular aperture of a common head-gate, under different heads.
2. By causing it to flow with a clear fall, over the edge of a waste-board notched 6 feet wide, and 9 inches deep, and placed in the tail-race, where it was 9 feet wide between the side walls.

The coefficients of discharge to be applied to the theoretical expenditure from the openings of rectangular gates and waste-boards, in order to determine the actual quantity of water passing in a given time, have been so fully settled by numerous experiments, that scarcely any more satisfactory mode of measurement could be devised.

In calculating the results of the following table, the formula used for the head-gate measurements is

$$^{*}\,Q = 0.625\sqrt{2gH} \times A;$$

where $Q$ = actual quantity of water passing per second in cubic feet.
$2g = 64\frac{1}{3}$ feet.
$H$ = the head in feet under which the water issued through the opening exposed.
$A$ = area of gate drawn in superficial feet.

This formula, to facilitate the calculations, is usually transformed into

$$Q = 5\sqrt{H} \times A,$$

in which shape we have applied it.

In the four experiments, where the waste-board was employed as a meter of the quantity of water used, it so happened that the depth of the sill beneath the surface of the still water above, was almost exactly the same as the depth of the notch, *or* 9 *inches*.

Now, for this depth the coefficient of discharge has been shown by Poncelet, and Lesbros, from actual experiment, to be 0.385, and hence the formula for the expenditure by the waste-board would be

$$^{\dagger}\,Q = 0.385\,LH\sqrt{2gH},$$

where $Q$ = quantity of water discharged per second.
$L$ = length of opening of waste-board.
$H$ = depth of the sill, or edge, below the level of still water = 0.75 feet in this case.
$2g = 64\frac{1}{3}$ feet.

computed by this formula, the flow over the waste-board was 12 cubic feet per second.

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[*] See Morin's "Aide Mémoire de Mechanique Pratique," edition of 1843, ps. 6 and 23.

[†] See Morin's "Aide Mémoire, p. 37.

But being desirous of enabling a closer comparison to be instituted between the experiments recorded in the following table, and those of Morin on the turbine of Müllbach, the writer has adopted, for the waste-board, the same formula that Morin used, viz.,

$$Q = 0.405\,LH\sqrt{2gH};$$

this formula gives a greater expenditure, and, of course, a lower coefficient of effect for the turbine than the former.

It will be borne in mind that in the following table the quantities of water used, actually include whatever leakage existed in the forebay, but as this did not seem to be very considerable, and as it was the wish of the writer not to undervalue the amount of water expended by this turbine, he did not think it worth while to measure and deduct the leakage referred to.

The turbine experimented upon, in this instance, has an exterior diameter of 4 feet 5 inches, its height is 6 inches, and throughout the experiments the lift of the sluice-gate was uniformly 4½ inches, or three-fourths of the full height.

With the view of ascertaining the statical force exerted by Dupont's turbine with 4½ inches gate drawn, weights were added in the scale, and the brake was screwed up, on two occasions, until the wheel stopped. It was then found that the standing power of this turbine, or the weight which it equilibrated, was 198 pounds at the end of a radius of 6 feet, when the fall was $4\frac{2}{10}$ feet, and 190 pounds under a fall of $4\frac{1}{10}$ feet.

These experiments offered also, to the eye, an excellent demonstration of the truth, that, when turbines run at their proper speed, the water drops from them *without velocity;* for when the wheel was stopped by the brake, the water rushing from the buckets with a velocity due to the fall, reacted violently from the walls of the tail-race, and produced a great commotion in the tail-water. But the moment the screws of the brake were relaxed, and the wheel had gained its proper speed, the tail-water became perfectly calm, and flowed away in a smooth, unbroken sheet; thus clearly showing that the water quitted the wheel without velocity, for otherwise it would have reacted from the walls, and disturbed the tail-water as before.

*Experiments made Oct. 3rd and 4th,* 1843, *by Alfred Dupont, Esq., and Ellwood Morris, C. E., upon the Turbine at the Powder Works, on the Brandywine, near Wilmington, Delaware.*

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of the experiments. | Vertical lift of the head-gate drawn to admit water to the Turbine. | Width of the head-gate drawn. | Opening of the head-gate drawn. | Head under which the water issued through the openings of col. 4. | Quantity of water used per second, or that which passed to the turbine thro' the openings of head-gate drawn in column 4. | Working fall during the experiments. | Theoretical velocity of water due to the working fall per second. | Theoretical Power in horses-power of 33,000 pounds lifted one foot high per minute. | Useful effect produced by the Turbine, as actually measured by the brake dynamometer of M. de Prony. | | | Ratio of the speed of the wheel at the inner circle, to the theoretical velocity of the water due to the working fall. | Coefficient of effect, or ratio of the power actually realized, to the theoretical power of the water. |
| | | | | | | | | | Revolutions of the wheel per minute. | Load of the brake at the end of a radius of six feet. | Horses power developed of 33,000 lbs. lifted one foot high per minute. | | |
| | Inches. | Inches. | Sup. ft. | Feet. | Cub. feet. | Feet. | Feet. | H. pr. | Revolu. | Pounds. | Hrs. pr. | Ratio. | Coeffi. |
| 1 | Water measur'd by waste-board. | | | | 12.63 | 4.1 | 16.2 | 5.6 | 25. | 119. | 3.4 | .254 | .578 |
| 2 | 6. | 30.75 | 1.28 | 2.4 | 9.92 | 2.9 | 13.6 | 3.3 | 28. | 63. | 2. | .332 | .606 |
| 3 | 18. | " | 3.84 | 0.46 | 13.02 | 4.7 | 17.3 | 7. | 36. | 119. | 5. | .336 | .714 |
| 4 | Water measur'd by waste-board. | | | | 12.63 | 4.1 | 16.2 | 5.6 | 39. | 91. | 4. | .389 | .678 |
| 5 | 31. | 30.75 | 6.62 | 0.208 | 15.09 | 4.9 | 17.7 | 8.4 | 49. | 112. | 6.3 | .447 | .750 |
| 6 | 18. | " | 3.84 | 0.5 | 13.57 | 4.6 | 17.2 | 7.1 | 50. | 91. | 5.2 | .470 | .732 |
| 7 | 12. | " | 2.56 | 1. | 12.80 | 4.2 | 16.4 | 6.1 | 48. | 80. | 4.4 | .473 | .721 |
| 8 | Water measur'd by waste-board. | | | | 12.63 | 4.1 | 16.2 | 5.6 | 50. | 73. | 3.4 | .498 | .712 |
| 9 | 12 | 30.75 | 2.56 | 1.1 | 13.44 | 4.2 | 16.4 | 6.4 | 52. | 70. | 4.2 | .512 | .656 |
| 10 | 12 | " | 2.56 | 1.1 | 13.44 | 4. | 16. | 6.1 | 56. | 63. | 4. | .565 | .656 |
| 11 | Water measur'd by waste-board | | | | 12.63 | 4.1 | 16.2 | 5.6 | 57. | 63. | 4.1 | .569 | .695 |
| 12 | 16 | 30.75 | 1.28 | 2.6 | 10.24 | 2.7 | 13.1 | 3.1 | 50. | 35. | 2. | .614 | .645 |
| 13 | 12 | " | 2.56 | 1.1 | 13.44 | 4. | 16. | 6.1 | 62. | 49. | 3.5 | .625 | .574 |
| 14 | 12 | " | 2.56 | 1.1 | 13.44 | 4. | 16. | 6.1 | 65. | 42. | 3.1 | .656 | .508 |
| 15 | 12 | " | 2.56 | 1.1 | 13.44 | 4. | 16. | 6.1 | 70. | 85. | 2.8 | .770 | .459 |

*Observations on the above Table.*—In the 1st, 4th, 8th, and 11th experiments, the turbine was entirely submerged to a depth of 28 ins., and in all the rest its top ran 18 inches under water.

The experiments from 1 to 3 inclusive, show that even with velocities, at the inner circle, ranging so low as from 25 to 33 per cent. of that due to the water by theory, the turbine realized, at an average, 63 per cent. of the full power of the water.

The experiments from 4 to 9 inclusive, show that when the turbine ran at a speed of from 40 to 50 per cent. of the theoretical velocity of the water (within which limits this wheel will always move,) it realized, at an average, about 71 per cent. of the theoretical power of the water; and the 5th experiment, which indicates the maximum effect, shows that when running with a speed of 45 per cent. of that of the issuing water, *its coefficient of effect reached seventy-five per cent.*

The experiments from 10 to 15 inclusive, show that with the high relative velocities of 50 to 70 per cent. of that of the issuing water, this turbine still retained an average useful effect of near 60 per cent.

The 12th experiment shows that even with a fall of but $2\frac{6}{10}$ feet, and though the wheel ran at too great a velocity, it still realized 64 per cent.

The above experiments, made with falls of water ranging from $2\frac{6}{10}$ up to $4\frac{9}{10}$ feet, and under a back-water equal to a third, or even a half, of the whole fall, corroborate those of Morin and others, upon these motors, and they prove, that whilst turbines possess a most singular power of adaptation to very different velocities without much loss of power, if their speed at the inner circle be confined within the limits of 40 to 50 per cent. of that due by theory to the issuing water, *we may safely calculate upon a useful effect of full seventy per cent.*

Before these pages issue from the press, there will be in operation *seven turbines,* constructed by Merrick & Towne, from the writer's drawings, to wit:—

One of 4 ft. 8 ins. diameter, driving a cotton mill at Rockland, on the Brandywine, in Delaware, with 6 ft. working fall.

One of 4 ft. 5 ins. diameter, driving a powder mill at Duponts, near Wilmington, Delaware, with 4 ft. working fall.

One of 4 ft. 8 ins. diameter, driving a woolen mill on the Crosswicks creek, New Jersey, with 7 ft. working fall.

One of 7 feet diameter, driving a heavy saw and plaster mill, on Millstone river, New Jersey, with 3 ft. working fall.

One of 6 ft. 6 ins. diameter, driving a woolen mill at Rokeby, on the Brandywine, Delaware, with 5 ft. working fall.

One of 3 ft. 2 ins. diameter, driving a grist mill on the Brandywine, near Coatesville, Pennsylvania, with 17 ft. working fall.

One of 6 ft. 6 ins. diameter, driving a large cotton mill at Phœnixville, Pennsylvania, with $8\frac{1}{2}$ ft. working fall.

These turbines varying in power from 4 to 30 horses, applied to different uses, running under various falls of water, and all of them placed so as to be more or less submerged by back-water, will demonstrate their utility, to practical men, in a manner which cannot be mistaken.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

## *Description of a Wrought-Iron Beacon erected at the harbor of Black Rock, in Long Island Sound, in the summer of* 1843. By W. H. Swift, Capt. Corps Topl. Engs.

We are indebted to the officer who erected this work, for the following description, which we have prefaced with a brief history, derived from authentic sources, of other structures erected in the same place, all of which have been, sooner or later, overthrown.

The vast magnitude and growing importance of the light-house establishment, and the large sum annually appropriated for repairs in this department of the general government, may render this brief history interesting.

The harbor of Black Rock lies about 18 miles westward of New Haven; it is accessible at extreme low water for vessels drawing 10 feet, and at high water it may be entered by vessels drawing from 16 to 18 feet. As a harbor of refuge it is more resorted to, perhaps, than any other in the sound, the depth of water being sufficient in all cases, for that class of vessels which are usually employed in the navigation of this great thoroughfare.

In 1829 a beacon of stone was built at this place under the orders of the Treasury Department, at a cost of about 6000 dollars. This beacon was entirely destroyed by a gale of wind in less than one month after it was erected. In the year 1835 it was rebuilt at an expense of nearly 9000 dollars: in the spring of 1836 it was injured by a gale of wind, so seriously that, in all probability, it would have been entirely demolished by the recurrence of the first heavy gale. It was then repaired with a guarantee from the contractor, that he would maintain the beacon in its position for a period of five years: this was effected at a cost to the United States of 6500 dollars. One year after the expiration of this guarantee, (in 1842) the beacon was again so much injured by a gale of wind, that the whole structure must have fallen, had not the long stones of which the upper part of the beacon was constructed, been held together in place by the wooden spar, or mast, which was used for supporting the cask; the stones were laid around this spar, and it served to prevent them from separating from each other. Thus, it will be seen, that within a period of 12 years, three stone beacons have been destroyed at this place, and that the cost to the United States has been upwards of 21,000 dollars.

In March, 1843, an appropriation of 10,000 dollars having been made by Congress, for rebuilding the Black Rock Beacon, the Secretary of the Treasury applied to the Secretary of War to allow this beacon to be constructed under the direction of the Chief Topographical Engineer, and by the orders of Colonel J. J. Abert, the work was entrusted to the superintendence of Captain W. H. Swift.

### *Description of the work by Capt. Swift.*

The beacon stands one mile and a half south of the entrance to the harbor, and is exposed to all winds from E.N.E.; around by the South to W.S.W.; from the East it is entirely open to the rake of the sea for a distance of sixty miles.

When the first beacon was built in 1829, a large quantity of pebble stone was carried in vessels to the proposed site, and there thrown into the water around a single rock called the "Old Huncher," and upon which there had been an iron spindle in former years; this rock was conical in shape, about 4 feet in diameter at top, and bare at very low water. Upon this loose stone, thus deposited, the superstructure was reared, and when the beacon was overthrown, the materials of which it was composed, were, of course, added to the rubble stone bed, and they, in turn, became the foundation for the beacon of 1835.

In the examination which I made of the site in June, preparatory to making the final plan for the iron work, I ascertained that the stone below low water, had, apparently, remained unmoved for a long time, and I subsequently found, by inquiring of Capt. Wilson, the contractor, who had repaired the beacon in 1836, and who had maintained it in repair for five years, that such was the fact; while, as he stated, and it was evidently true, the stones between low and high water were thrown about by the force of the sea in every gale. This was fully exemplified too by the appearance which the injured part of the old beacon presented; the base, or that part below low water was entirely undisturbed, the breach being between high and low water marks; all the stone below low water remaining, as stated by Capt. Wilson, as they were when the beacon was repaired in 1835.

There being no stone of sufficient size at the old beacon into which the iron shafts of the new structure could be secured, I found it necessary to procure elsewhere such as were suitable for the purpose, and to transport them to the site, and imbed them below the line of low water, in order that the sea might not disturb them after they should be laid.

### *Description of the stone foundation.*

The beacon, according to the general plan which I had made, and submitted to Col. Abert on the 30th of April last, was to be elevated 36 feet, and for this height I decided to give the iron shafts a spread, or base, of 16 feet, with an inclination towards the centre of about 1 to 6. In order that there should be sufficient strength in the stone to resist any tendency there might be to fracture at the holes which were to receive the feet of the shafts, I adopted the dimension of 20 feet as a suitable diameter for the stone bed designed for the shafts to be secured to; this dimension gave a distance of about 2½ feet from the centre of the shaft holes to the edge of the stone at top, while at the bottom of the stone, where the strain is less, it would be 2 feet. The bed then is composed of 6 pieces of hammered granite, 2½ feet thick; the middle stone is round, and is 8 feet in diameter, the five outer stones are 6 feet wide by about 12 feet in length, each stone weighing nearly 12 tons; the stone are cramped and doweled together with 1½ inch round copper, two at each joint, the cramps 2 feet long, and the dowells 10 and 12 inches long.

The excavation which was made in what may be called the artificial island (for at low water an extent of 105 ft. from east to west, and 88 ft. from north to south is exposed,) for the reception of the stone bed is a few feet N.W. from the old beacon, it was 26 feet in diameter, and 3 ft. below *ordinary* low water. When the excavation was completed, a layer of concrete, composed of 5 parts of hydraulic lime, to 8 parts of sand, was spread over the bottom of the pit by means of a trough of wood for the foundation stone to rest upon. After the stones were laid, which was effected by means of a heavy pair of shears, and a "Lewis," the unoccupied space in the pit around the outside of the stone bed, was filled with concrete and rubble stone flush with the top of the foundation stone. As it was only at, or near, low water that this part of the work could be carried on, that is to say ordinarily, about three hours per day in good weather, considerable time was necessarily consumed in getting in the foundation; from the day the shears were erected to the day the stone work was completed, was just five weeks.

## *Description of the Iron work.*

The figure of the beacon is that of a truncated pyramid; it is formed of six wrought-iron shafts, five of them 36 ft. 7 ins. in length, standing in the periphery of a circle of 16 ft. diameter, and one 36 ft. long at the centre, the outer shafts incline towards the middle in such proportion, as to fall at the top within the circumference of a circle of 3 ft. diameter; each of these shafts is composed of two pieces of equal length, the diameter at the foot of the lower piece is 5¼ ins., and at the top 4 inches; the diameter of the upper piece is 4 ins. at the foot, and 3 ins. at the top, they are united by a cast-iron socket of 3 ft. in length, 2½ ins. thick at the joint of the shafts, which is at the middle of the socket, 2 ins. thick at the top and bottom, and 1 inch thick elsewhere; the top of the lower shaft is made concave, and the bottom of the upper shaft convex, fitting one into the other. At the distance of one foot from the joint of the shafts, a steel key 2 inches deep by ¾ of an inch wide, passes through the socket and each shaft to secure them together; the sockets inside, and 18 ins. of the ends of the shafts are turned and accurately fitted to each other. At a distance of 2½ feet from the foot of the lower shafts, are 4 shoulders one foot long, and projecting, at the lower extremity, one inch from the shaft to form points of support for the same at the surface of the foundation stone. Above and below the joints of the shafts, and at distances of 9 ft. and 18 ft. respectively above the top of the stone, are two sets of braces extending from the middle shaft to each outer shaft, and from one outer shaft to another, making ten in each set; the braces are of wrought-iron 2½ ins. square, the extremities are secured by 1¼ inch screw bolts to cast-iron collars, these collars are strengthened by two wrought-iron bands, and are firmly attached to the shafts by steel keys; the space between the collar and shaft, and between the keys is filled with zinc; the braces are secured to the collars in such a manner that they serve for ties in case of any unforseen strain acting from the *interior* of the beacon, such as might possibly be occasioned by ice, or any other floating body.

The top of the shafts are provided with shoulders to support a cast-iron cap, composed of five arms, each 3 ft. in length, and 4 ins. in width, strengthened by a rib, or flanch, of 3½ ins. in depth; the shafts pass through this cap 18 inches from the centre of it, and are there keyed in place; a wrought-iron band 3 ins. wide, and ½ inch thick, is shrunk upon the extremity of these arms to add to its strength; from the ends of the arms of the cap, 3 ft. from the centre, braces of 2 ins. round iron descend 4½ ft. to the main shafts, and are there secured by screw bolts passing through their extremities, and through the shafts also. At this junction of the braces with the shafts, a wrought-iron band, similar to that which encircles the cast-iron cap, is fitted and bolted at a distance of 4½ ft.; again below this second band is a third band similar to the two others, and similarly secured by screw bolts through the shafts; finally, there are 10 panels, or gratings, 4½ feet long, corresponding in shape and dimension with the wrought-iron bands between the shafts, and the wrought-iron bands; these gratings are made of boiler iron $\frac{3}{16}$th of an inch thick, with eight horizontal and 3 vertical slats, or bars, 3 ins. wide, riveted together; the horizontal slats are 3 ins. apart, but at the distance of 500 yards, the top of the beacon presents the appearance of an opaque body 9½ ft. long by 6 ft. wide at the top and bottom, and 4½ ft. wide midway of the same.

The feet of the iron shafts penetrate the stone foundation 2½ ft., and are secured in their places by heavy iron wedges fitted to the unoccupied spaces between the sides of the holes in the stone and the shafts; the holes being inclined, and the braces between the shafts being immovable. It is evident that the feet cannot be withdrawn from their places without rupture. Now, the braces are of 2½ inch square iron, and the thickness of the stone outside of the hole is 2½ feet, and this would seem to present sufficient strength to resist a shock from any ordinary cause.

In addition to the concrete around the outside of the stone, and the cramps and dowells to secure the same together, there are five iron ties of 1½ ins. diameter, extending from a collar of two inch wrought iron, which surrounds the middle shaft, to each of the outer shafts to which they are firmly and securely attached by means of heavy iron stirrups; the ends of the ties are furnished with screws and nuts, and by this means can be kept in a constant state of tension. This arrangement was resorted to as an additional means of preventing any tendency there might be in the outer foundation stones to separate themselves from the middle stone.

The beacon, as finished, stands 34 ft. above low water, and 3 ft. higher than the old beacon; the cage, or grating, is painted black, and the shafts vermilion red.

A model of the work upon a scale of one inch to a foot will be deposited in the Bureau: this, with the accompanying plan in detail, will convey all the information in reference to the construction which may be required.

The iron work was executed in Boston by Messrs. Cyrus Alger & Co., under the immediate superintendence of Mr. Lester; the entire weight is upwards of 19,000 lbs. The foundation was prepared, and the beacon erected in place by Mr. Benjamin Pomeroy, of Stonington, Ct., under a contract made with him for that purpose. The entire cost of the iron work and foundation was about 4600 dollars, and the time consumed in the construction was three months.

I had it in contemplation at one time to coat the iron work with zinc, by means of electro-galvanism, but I found that too much time would be required for preparing the necessary tanks and apparatus. I venture to hope, however, that another occasion may present itself, and that in the more important structure of the "screw pile light," which, I trust, I shall one day see executed upon our own shores, that the galvanizing process may be successfully applied.

In conclusion I beg to call attention to one or two of the more important advantages which this application of one of the principles of Mitchell's Screw-pile, to the construction of light-houses and beacons, presents.

In a very exposed situation, a light, or a beacon, if built of masonry, can only stand when the best description of work is introduced; this, of course, involves great expense, and much time. The mode of construction for such situations must, in principle, be similar to that adopted for the Eddystone and Bell Rock lights, and this, as all know who understand the subject, would, in the case of our own coast, present *an insuperable objection;* for example, the Bell Rock Light, on the coast of Scotland, cost £360,000, or 1,800,000 dollars, and four years were required to build it, this too in a situation where the rock upon which it is placed is bare at low water. The Eddystone was neither so costly, nor did it require so much time to complete it, still $ would, with us, justly be considered out of the question for a single light.* There are many places upon our coast at which the screw pile light could be erected at a very moderate cost, far less, indeed, than that of a light ship; notwithstanding this there are at this time not less than floating lights in Pamlico Sound, on the coast of North Carolina. The Middle Ground, in Long Island Sound, upon which there are only 3 feet at low water, and at which a light boat is now maintained, is, of all others, the most suitable point to make the first experiment upon with this description of light.

In reference to the durability of wrought-iron exposed to the action of sea water, I have not a great deal of information to impart, still I have some which bears upon this question. Upon many of the reefs in Long Island Sound, and more particularly in Fisher's Island Sound, it has been the practice for many years to erect wrought-iron spindles of about 4 inches diameter, and from 15 to 25 feet in height; such spindles last from 15 to 20 years, unless carried away by ice. The contractor who placed several of these spindles, informed me that one upon a reef in Fisher's Island Sound had been up 20 years without being renewed; the wasting takes place principally between high and low water, and in this particular case, the size of the spindle is reduced from 4 to 2 inches in diameter. If, however, the zincing process, or if a precipitate of copper, be resorted to, there is every reason for believing that the iron thus protected would last twice, or three times, 20 years. In short, economy in cost and in time, and the application of the principle of the screw pile in situations where masonry could not be resorted to without inordinate expense, would seem to be advantages in themselves sufficient to justify extensive experiments in a branch of the public service of such importance as that of our light-house system.

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* The Car Rock Beacon, on the coast of Scotland, cost 25,000 dollars; six years were required for the construction; it was intended to build it entirely of stone, but when half finished the upper part was constructed of cast-iron. The cast-iron beacon on York Ledge Maine, is an exact copy of the Car Rock Beacon: it cost 10,000 dollars.

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## *Mr. Vignoles' Lectures on Civil Engineering, at the London University College.*

(Continued from page 306.)

### LECTURE XVI.—WORKING EXPENSES OF RAILWAYS—*(Continued.)*

The result of the examination into the expense of passenger traffic had been investigated in the last two lectures, and a general average cost had been deduced, varying from two-thirds of a penny to one penny per mile per passenger, including the Government duty, the fraction varying, of course, with the number of passengers in the train. It would not be necessary to go as minutely into the items of corresponding expense of merchandize and mineral traffic, nor would this last lecture but one of the course allow sufficient time to do so. Mr. Vignoles said he should endeavor to compress what he had to explain further about railway expenses into this evening's address, and, in the concluding lecture, he would take a general review of the whole of his course on railway matters. The cost of carrying coals, at very moderate velocities, on the great colliery railways, is about one penny per ton per mile, which may be divided into the following heads, viz:—

*Expense of Transport of Coal.*

| | Dec. of a penny. |
|---|---|
| Locomotive power, - - - | .38 |
| Wagons, - - - - | .19 |
| Conducting traffic, - - - | .08 |
| Maintenance of railway, - - | .21 |
| General expenses, including local taxes, | .14 |
| Per ton of coal per mile, - | 1.00 |

The proportion of the weight of the coal to the gross load carried being as 3 to 5. The expense of carrying goods on the Liverpool and Manchester Railway, taken on the average of seven years' traffic, appears to be about 2½d. per ton per mile, divided as follows:—

*Expense of Transport of Merchandize.*

| | Dec. of a penny. |
|---|---|
| Locomotive power, - - - | .57 |
| Wagons, - - - - - | .23 |
| Conducting traffic, - - - | 1.08 |
| Maintenance of railway, - - | .31 |
| General expenses, including local taxes, | .35 |
| Per ton of goods per mile, - | 2.54 |

But in this sum is included a considerable item, which does not properly belong to the railway itself, viz., the cost of collecting and delivering the goods all over the towns at the two termini, by carts and wagons, and full ½d. per ton may be taken off for this item—making the total expense 2d. per ton per mile—the proportion of useful weight, of weight of merchandize carried, to the gross weight, including the wagons, being as 1 to 2. We have now the results of many years' working expenses of railways for passengers, as we have investigated in the two last lectures, and, as above, for coal and merchandize, which may be tabulated thus:—

*Expense of Railway Transport per mile.*

| | |
|---|---|
| Passengers, at high velocities, - - - | 1d. each. |
| Coal, at very moderate speed, - - - | 1d. per ton. |
| Merchandize, at fifteen miles an hour, - - | 2d. " |

Reducing the expenses of passenger traffic to a tonnage—taking the weight of twelve passengers and their luggage as being, on the average, equivalent to a ton—we obtain 1s. per ton per mile, which is twelve times the expense of carrying coal, and six times that of conveying goods. A portion of this difference, but not all, is due to the velocity, for, though it would seem that this doubles the cost of goods, as compared with coals, it is not so in fact, as a large proportion of expense is incurred in the handling and office work necessary for merchandize traffic, to which coal is not liable. Comparing the proportion, between the useful, or paying, load, and the gross weight moved, including the vehicles, we have, coal 3 to 5, merchandize 1 to 2, and, as explained in the preceding lectures, passengers 1 to 6, and often more. The consideration of the comparative view in this light led Mr. Vignoles to observe, that, notwithstanding the apparent difference, there is a great analogy between the proportion, as regards goods and passengers, for, if the passenger trains could be fully loaded, the proportion between the profitable, and the gross, load, would be nearly the same, both for passengers and merchandize, the result being almost similar, as regards the actual weight to be transported, and the preparation to be made for moving the mass—at the same time, it was an additional and collateral proof that the figures laid down in the above general terms, by the Professor, might be depended upon. On colliery and mineral railways the traffic is arranged so as to carry the *maximum* profitable load on a *minimum* weight of vehicle; supposing coal and merchandize were really conveyed on equal terms in every thing except speed, the difference in velocity would appear to effect a saving of one-half. This, however, is not the case; the difference of expense due to velocity, may, perhaps, be stated at from .50 to .60 of a penny per ton per mile as a *maximum;* the remainder of the difference is chargeable to the mode of conducting the traffic; and, in reference to the passenger trains, it should be borne in mind, that it is the necessity of meeting the fluctuation of passenger traffic, and, in order that the public may be accommodated, that, taking weight for weight, it costs railway companies six times as much to convey passengers as to transport goods. On the other hand, ten years' experience of the working of the Liverpool and Manchester Railway produces the result that their profit upon the conveyance of a single passenger averages the same as the profit on the carriage of a ton of merchandize. But why? On that line, there being a great competition with the river and canal navigation, the rate of charges for goods has been brought down to the lowest terms, for the utmost possible extent of accommodation of warehousing, delivery, &c.; but there being a practical monopoly in the conveyance of passengers, the fares are not quite to a *maximum*, but still very high. Mr. Vignoles observed, in applying these facts, that it had been one of the objects of these lectures to show, and he wished to enforce it on the minds of the class, as a useful and easily attainable result, that, by sending trains more frequently, with fewer carriages, and by constructing those carriages to a better proportion between the paying and the unprofitable load, the increased accommodation would bring increased traffic; for, considering that the expense of transport is but little affected by the number of passengers, by such increase the expenses, as computed per passenger per mile, might be fairly calculated as susceptible of being reduced from 1d. to ½d.; supposing every other condition to be as at present: another advantageous consequence would be that of keeping the engines above their work. Such an arrangement of trains bore greatly upon the important question of what amount of extra expenditure on railways could be fully justified by prospectively consequent beneficial results; but the Professor said he would not again enter into the question of gradients. The necessity of perfect gradients assumed *maximum* loads as generally occurring, whereas exactly the opposite was the case in practice, especially with passenger trains, and on lines in districts not adjacent to the metropolis, or our largest commercial and manufacturing towns; indeed, it is remarkable how nearly alike in all railways, whose gradients differed greatly, were the working expenses per train per mile. On the North Union Railway, for example, where five miles out of twenty-two are at an inclination of fifty-three feet per mile, the mileage expenses of working trains is quite as small as upon railways of which the gradients are nearly horizontal; and it was found that up to six or eight carriages, or from that number even up to ten vehicles per train, no very material mileage difference of working expenses results on lines with what are called comparatively favorable, or unfavorable, gradients. Mr. Vignoles then referred to a former lecture, wherein he had considered how far beyond 10,000*l.* per mile, as the total cost of any given line of railway, it was justifiable to incur increased expense in the formation, to obtain more perfect gradients, or to make the railway at all. He observed that the late Irish Railway Commissioners had distinctly shown by a different process of reasoning, and on different data, that any excess above this sum could seldom be advisable in agricultural countries, or where the traffic was inconsiderable, and the Professor strongly insisted that it was more expedient to encounter inclinations of fifty, sixty, or even eighty, feet per mile, with lighter trains, or heavier engines, and at a somewhat greater cost of working per mile, than to incur the expense of vast excavations and embankments, and costly works of art, to obtain better gradients. He particularly referred to his own practice in this respect, and to his report to the above commissioners on the laying out of the railways in Ireland, and observed that the French engineers had fallen into a great mistake in proposing such expensive sections for the French lines. On the Liverpool and Manchester Railway, and, indeed, on several other lines, the expense of locomotive power was only about one-fourth of the whole cost of transport; but, supposing it to be as much as one-third, it would be found that not a third part of this third, or not more than one-ninth part of the whole working expense, was effected by the gradients, and nearly all other expenses, beyond increased fuel and repairs, on account of steep inclinations, were common to all lines, and depended upon management rather than the gradients. If the number of miles run by engines with trains, and the total annual cost of working various railways, were taken, and also the corresponding amount of gross receipts and net returns per train per mile, and a comparison made with the interest of the capital expended, it would be found that on very few lines, indeed, had the vast expense of obtaining good gradients been justified. Mr. Vignoles observed that, having determined the cost of conveying goods and passengers, as before explained, and having ascertained the probable amount of traffic, it would be found that the public could seldom afford to pay higher charges than such as, in addition to the cost to the company, would leave them a profit per passenger per mile of 1d.; per ton of goods per mile of 1d.; per ton of coals per mile of ½d. On the continent the people could not give half the above, and so in Scotland and in Ireland; any increase driving the traffic into other channels, as in the case of the Paisley and Greenock Railway, or, perhaps, stopping it altogether. On the great traveling lines monopoly entirely kept up higher prices, but intercourse was thereby greatly impeded, and the public suffered, and the traffic returns published, showed that the limits of receipts had been attained on many of them. On the Dublin and Kingstown Railway the average expense of conveying passengers was only ½d. per mile, and the profit to the company a trifle above that figure—say, about five-eighths of a penny per passenger per mile; this low fare produced a steady and regular increase of intercourse. The profit to the great English railway companies was about 2d. per passenger per mile, which was, perhaps, often not more than what was requisite to pay for the great, and, as the Professor argued, the useless, increased expense of these principal lines, but the traveling public paid dearly for it. Mr. Vignoles observed, in conclusion, that, what he had stated were sure and simple data by which the working of the existing and future railways might be dissected, and a judgment formed on how far it was advisable to have spent 250,000*l.* per mile on the Greenwich and Blackwall Railways, and an average of 50,000*l.* per mile for many lines whose prospects could never have justified it, particularly if *à priori* investigations, such as those here gone into, had been instituted.

To be Continued.

## Franklin Institute.

*Address of* JOHN WIEGAND, ESQ., *Chairman of the Committee on Exhibitions, preceding the reading of the Report of the Committee.*

*Ladies and Gentlemen,*—In conformity with our arrangements, we meet you this afternoon for the purpose of presenting our report on the Exhibition of American Manufactures, which is now before you, and of distributing the Premiums, and other honorary distinctions which we have had the pleasure to award. It is with no ordinary gratification that we perform this duty. Before proceeding to discharge it, we feel that our warm congratulations should be exchanged upon the triumphs of American industry, which are spread out in such rich variety and excellence in these spacious halls. Compared with the first exhibition of the kind held by the Institute, in the year 1824, how great have been the improvements, and how wonderful the changes we witness. We remember how limited in variety, and how imperfect in finish, were the specimens then exhibited.

It is but a few, a very few, years since, that the hope was, in any degree, entertained that we might be able, as a nation, to supply our own domestic wants.

A few short years, and we have even more than realized our most sanguine desires: we now stand forth competitors with the great manufacturing nations of the world. All this, too, has been accomplished in a period of time so short, when compared with the rise and progress of manufactures in Europe, that we can scarcely believe the evidence of our senses. It seems more the work of magic, than the result of our own skill and enterprize. All this, too, has been attained in the teeth of old and almost inveterate prejudices; and it is mainly these, which, at this hour, secures employment for the workshops of Europe. Thanks to the skill of our artisans, thanks to an intelligent community, these prejudices are being dissipated; and by stimulants such as these exhibitions afford, and by the dissemination of sound practical science, we may yet see our own manufactures universally preferred: and without the slightest purpose to pay a flattering compliment, may we not add, that, with our fair countrywomen rests much of the patronage which the arts require? And shall they not receive it?

We are not of the number of those who hold in horror a manufacturing population. We do not believe that such a class will be ever overworked, or starved, in this country. It is too capacious for such results. When we contemplate the extent of territory, the variety of soil and climate, and the difference in habits and pursuits, which these induce, we will, undoubtedly, come to the conclusion, that here all is presented which is calculated to lead to that diversity of occupation which is the true basis of individual and national prosperity.

Manufacturing establishments and towns we will, undoubtedly, have: we have them even now, and they are distinguished for their order, intelligence and morality, no less than for their industry.

But our manufacturing establishments will be located just where they can be conducted most advantageously for obtaining supplies, and securing a steady and profitable market—they will keep pace with population and wants. The extent of our country precludes the idea of any one section becoming the entire manufacturers for the other sections of the country; particularly of such articles as are indispensable to the wants and comforts of society. We already see such establishments springing up in the south and west; and we expect to see, in every State possessing the proper requisites, a due proportion of manufacturing establishments.

Our citizens understand their interests too well to send the produce of their farms, by long and expensive routes, to a market, and by the same expensive routes to obtain all their supplies of manufactured goods. They will have in their midst the artisan who can manufacture for them, and who will, at the same time, become a steady and profitable customer for agricultural products.

While we entertain these views, we freely admit that there are locations, which, from their peculiar facilities for obtaining all the material for manufacturing, and for distributing goods, must ever possess decided advantages for manufacturing purposes. Such a position is enjoyed by Philadelphia, and it may not be out of place here to remind the citizens of our own loved city, that if Philadelphia is to live and prosper, it must be mainly by the production of her own workshops. The field is large, and the harvest inviting and rich. If we fail to reap it, it will be because we are too blind, or indolent, or what may be equally as fatal, too cautious and hesitating in our movements. "There is a tide in the affairs of" cities, as well as of "men, which, when taken at the flood, leads on to fortune."

It is not our purpose to notice the objections urged against a manufacturing population, drawn from their condition in Europe. All that we ask is to let a due proportion of the generation, which are now enjoying the advantages of our public school system, become our mechanics and artisans, and all fears on this subject will be forgotten; and so long as an useful education is provided for every child in the State, such evils cannot long exist. It is wrong, it is unjust, to suppose that intelligent mechanics and artisans are less qualified for self-government than other classes of society. Intelligent industry dangerous? Why, it is a nation's best security.

This is not the time, nor is it any part of the object of the Franklin Institute, to discuss questions of political economy. The Institute, however, is founded upon the presumption, that, as a great nation, we must and will provide for all our wants and comforts:—no nation can be independent without it.

The objects of the Franklin Institute are the promotion of the mechanic arts; whatever, therefore, will secure these objects, whether it be in the lecture room, the laboratory, by scientific investigations, by publications, or by exhibitions of American skill—these, one and all, the Institute will most unremittingly employ.

We must be pardoned for taking this occasion to speak of the claims of the Franklin Institute upon the citizens of Philadelphia. We do not think that we can be chargeable with presumption, when we say that the Institute has claims, not only upon the manufacturer and artisan, but upon all whose prosperity is involved in the prosperity of Philadelphia.

The Institute has, thus far, been sustained mainly by the labors of a comparatively few zealous, disinterested friends of science and the arts; they have done all and more, by contributions of time and money, than could have been reasonably expected, or asked, of them. The Institute, by attempting too much, has become embarrassed, and its friends must appeal to the citizens of Philadelphia for aid to extricate it from its difficulties, or it may drag on a sickly existence, and, possibly, perish. Should our citizens permit such a result, it may then be found that Philadelphia has lost one of the chief stimulants and aids which has given the productions of her workshops a character unsurpassed, if not unrivaled, by those of any other city in the Union.

The Committee charged with the care of this exhibition would not do justice to their feelings, did they not here acknowledge their indebtedness to the gentlemen composing the Committees of Arrangement and of Judges, who contributed so much valuable time and aid.

In presenting this report, it is due to the makers of the articles deposited to say, that, with very few exceptions, the specimens exhibited are but fair samples of what may be obtained at all times from the manufacturers, or their agents—they were not made with special reference for this exhibition. And it is also proper to say that each specimen has been subjected to a rigid scrutiny, and has not only been compared with similar articles of domestic make, but has also been brought into close comparison with similar articles of old established European makers.

The judges are disinterested men, entirely independent of the parties interested in the issue, and have been selected on account of their practical acquaintance with the articles submitted to their inspection.

It is a subject of regret to the Institute that many beautiful specimens of art, which grace the exhibition, and reflect great credit on the makers' skill and taste, were not deposited within the time prescribed, and, consequently, could not come under the inspection of the judges.

All that we can report at this time is a list of those articles, which, for their superior excellence, have obtained the award of a premium, honorary mention, or special notice. The report of the judges, in detail, will appear in the Journal of the Institute. As the awards of premiums are read, the President of the Institute will present them to the parties entitled to receive them.

We are also instructed to say, that if any article deposited within the prescribed time, has been omitted by the judges, or, in the preparation of our report, such omission will be corrected, and the article, if entitled to an award, will be reported on immediately before the address, on the last day of the exhibition.

## REPORT.

*On the Thirteenth Exhibition of American Manufactures, held by the Franklin Institute of the State of Pennsylvania, for the Promotion of the Mechanic Arts.*

The Committee on Exhibitions of the Franklin Institute respectfully Report :—

That the exhibition, the awards in regard to which the Committee is about to publish, far exceeds any previous one held by the Franklin Institute. The labors encountered by the members, who were active on the different committees, and the exertions of the depositors have been amply rewarded by the result produced.

It was doubted by many whether the splendid accommodations which the halls of the Museum building afford, were not too extensive for the purpose of our exhibitions. With several departments of manufactures, less fully represented than might reasonably have been expected, we have had abundance from others to fill the space provided, and that bountifully, as well as beautifully. The useful and the ornamental have contended for the palm of public favor, and the throngs which have examined these specimens of native skill and ingenuity, have been more than satisfied, highly gratified, with the increased number and interest of the products set before them, and with the increased facilities for a close examination of the separate specimens.

The usual notices of the time of beginning the exhibition, and of the rules under which it would be conducted, have been rendered public for several months, thereby giving ample time for forwarding, and even preparing (in cases where it was deemed desirable,) articles for exhibition, and preventing, as far as practicable, those mistakes which sometimes deprive deserving competitors of the fruits of their skill, by nonconformity to established rules. Notwithstanding the efforts of the committee in this respect, and of those of the committee of arrangement, many depositors brought articles too late for examination, which otherwise would doubtless have met with attention, and in many cases the reward of the honors of the exhibition.

Under these rules the exhibition opened on Tuesday last, the 17th of October. The activity of the committee of arrangement, to whom the thanks of the Institute are due, gave, at an early date, an earnest of the present happy conclusion of their labors, and if in some cases their just expectations were not realized, the experience gained will be useful on future occasions.

The manufacturers and artisans have fully met the wishes of the Franklin Institute, and of the public. The display of goods in some departments is exceedingly beautiful; the printed cotton goods have attracted universal attention, and received the highest praise; the woolens are thrown into the shade only by the cottons; the silk goods give promise that this branch of manufacture is firmly established among us; the carpets are of beautiful texture, and excellent color, and of a considerable variety of kinds; the oil cloths, which have been improving from year to year, are admirable; the hardware and cutlery are of great variety, and excellent quality, many articles entirely superseding the use of the foreign ones; the iron and steel keeps its rank: the exhibition of lamps and gas fixtures surpasses all former ones; the stoves and grates still improve; the cabinet ware and furniture take a new rank for beauty of form and exquisite finish; the musical instruments improve greatly in average quality; the books and stationary, the bookbinders' tools, the chemicals, the straw goods, the surgical instruments, the paints and colors, maintain their rank, and some of the departments have even advanced; the hats and caps, the coach work, the leather and morocco were exhibited in quantities, and of a quality, to satisfy all; the boots and shoes are excellent; the philosophical apparatus has manifestly improved. These are among the departments which have chiefly contributed to give to this exhibition the character already assigned to it.

The committee has closely adhered to its published programme, in the arrangements of the exhibition, and, aided by the promptness of the committee of judges, is now prepared, on the appointed day, to publish the awards made by them to the makers and depositors of articles examined.

In presenting the results of the reports of the judges, and of their deliberations upon them, the committee intends to be very plain in speaking of the merits, or demerits, of different departments of the exhibition. The real, substantial merits of the whole are too great to be depreciated by such a course. The committee feels too certain of this to fear. On the other hand, our mechanics and manufacturers, and the public, all of them parties whom the Institute should serve, will gain by candor. The Franklin Institute, the committee trusts, will never attempt to make capital by flattering words, or undue praise.

## I.—*Cotton Goods.*

The display of Cotton Goods, especially of Cotton Printed Goods, was the pride of the exhibition, reflecting great credit on the establishments whence they came. Their tasteful display by the depositors, under direction of the committee of arrangement, rendered the specimens exceedingly effective. When the material, as well as the printing, shall be American, there can be nothing more to be desired in this department, but its regular and steady forward movement with all other branches of art. The beautiful variety of patterns, the skill in the combination of colors, the exquisite beauty of the colors themselves, could not be examined without glowing admiration.

The awards in this branch will be found liberal, in proportion to the excellence just set forth. The committee has followed closely the recommendation of the judges.

No. 2, by Benjamin Marshall. of New York Mills, Whitestown, New York, deposited by John W. Downing, fine bleached longcloths, "believed to be the best ever made in the United States," and rivaling the British longcloths. A Silver Medal.

Nos. 150 to 155, by J. Dunnell & Co., Pawtucket, Rhode Island, for beautiful printed cotton goods, "combining elegance of design, brilliancy of coloring, and accuracy of execution in an extraordinary degree," deposited by David S. Brown. A Silver Medal.

Nos. 13 and 173 to 179, by Benjamin Cozzens, Providence, R. I., for beautiful printed goods, combining the same qualities with the articles last named, deposited by Lippincott, Way & Wolcott, and by Austin Scott. A Silver Medal.

No. 202, by A. Robeson & Son, of Fall River, Mass., deposited by Hacker, Lea & Co., printed cottons and printed lawns, of qualities enumerated in the foregoing. A Sliver Medal.

Nos. 188 to 197, and 199 to 201, by Perkins & Wendell, of Bustleton, Philadelphia county, deposited by David S. Brown & Co., and by C. W. Churchman, a superb display of printed cottons and printed lawns, balzerines, and mousselines de laine, possessing the same qualities as the foregoing. A Silver Medal.

It is to be understood that the last four awards are made for the printing of the goods.

No. 49, Preston longcloths, by the Lonsdale Company, Providence, R. I., an excellent shirting, deposited by Wood & Abbott.
A Certificate of Honorable Mention.

No. 20, by R. Beath, of Philadelphia, Earlston ginghams, deposited by Sharp, Lindsay & Haines, a good article, the finish improved upon former specimens. A Certificate of Honorable Mention.

No. 40, by Hood, Simpson & Co., of Philadelphia, ginghams, in imitation of the Manchester ginghams, deposited by John Simpson.
A Certificate of Honorable Mention.

No. 47, by John Elliott, of Philadelphia, deposited by Bingham & Kintzle, well made imitation linen diaper.
A Certificate of Honorable Mention.

No. 9, by Thomas Brown, of Blockley, Philadelphia county, deposited by E. Pilling, of Philadelphia, very good striped tapes.
A Certificate of Honorable Mention.

No. 233, by James Wright, of Philadelphia, Turkey red yarn, much improved upon the specimens submitted last year.
A Certificate of Honorable Mention.

Nos. 159 to 165, the American and Hamilton Print Works, and Joseph Ripka exhibit favorable specimens of their skill.

### II.—*Woolen Goods.*

The specimens in this branch were highly creditable to the manufacturers.

The judges recommend, and the committee makes the following awards:—

Nos. 100 to 106, by S. Slater & Sons, Webster, Mass., deposited by D. S. Brown & Co., black cloths, wool dyed, beautifully finished, regarded by the judges as the best in the exhibition—a silver medal.

Nos. 117 to 122, by Edward Harris, of Woonsocket, R. I., deposited by David S. Brown & Co., merino cassimeres, very superior, and showing great improvement—a silver medal.

Nos. 58 to 95, by the Middlesex Manufacturing Company, of Lowell, Mass., deposited by Stone, Slade & Farnum, cloths and cassimeres, of good quality—a certificate H. M.

The judges notice with approbation Nos. 131 to 133, by the Gonic Company, Rochester, N. Y., superior blankets, deposited by David S. Brown & Co.; Nos. 134 to 144, by W. & D. D. Farnum, Waterford, Mass., deposited by D. S. Brown & Co., fancy cassimeres; No. 226, by James Martin, of Philadelphia, four vest patterns, considered to be beautiful specimens; No. 252, by John H. Ewing, Washington county, Penn., deposited by Farnum, Newhall & Co., four pieces of wool.

### III.—*Carpets and Oil Cloths.*

Few departments of the exhibition attracted more attention than this from the intrinsic excellence of the specimens, and the superiority over exhibitions of former years.

In compliance with the indications of the judges' report, the committee awards:—

No. 21, by W. H. Knight, Saxonville, Mass., deposited by W. D. Hasting, a beautiful specimen of fine ingrain carpeting, the best exhibited—a silver medal.

No. 211, by Andrew McCallum & Co., Germantown, Philadelphia county, the best specimen of Brussels carpeting exhibited—a silver medal.

No. 25, by John Rosencrantz, Manayunk, Philadelphia county, a superior velvet-pile carpet—a silver medal.

No. 227, by Isaac Macauley & Co., of Philadelphia, oil cloths for floors, of large size and excellent quality—a silver medal.

The table oil cloths of Andrew Johnson, of Cincinnati, Ohio, No. 27, fully sustain the reputation of the manufacturer.

### IV.—*Silk Goods.*

The increasing number and variety of articles in this department give evidence, year by year, of a steady and regular growth. The judges appeared to have examined the various articles minutely, and in accordance with their recommendation, the following awards are made:—

No. 224, by John W. Gill, of Jefferson county, Ohio, a collection of silk goods of various kinds—a silver medal.

This collection includes quantities of from one to twelve yards of heavy triple piled velvet, eight thread satin vesting, figured vesting, black serge, flowered silk, colored cravats, handkerchiefs, heavy crimson, white and blue amozine, black and white silk stockings, &c. The raw silk is understood to be grown by the farmers in the neighborhood of the manufactory.

No. 30, by the New York Dyeing and Printing Company, Staten Island, deposited by Mitchell, Brognard & Co., thirty-four pieces of Pongee handkerchiefs, the printing executed in this country—a certificate H. M.

No. 50, by the Philadelphia Silk Manufacturing Company, deposited by J. C. Coppuck, one case of sewing silks, considered by the judges to be the best in the exhibition—a certificate H. M.

The judges mention with approbation, specimen No. 222, fifty pieces of union galloons, by Edward S. Richards, of Philadelphia, deposited by Piggott & Richards.

They likewise examined specimens of gloves, and speak well of No. 5, two dozen pairs of men's royal buck gloves, by John J. Tavener, of Johnstown, N. Y., deposited by Bettle Paul, the article being one which may compete successfully with the foreign.

They recommend, and the committee awards, to 221, by Enos Cooper, of Philadelphia, one dozen and a quarter of men's kid gloves, considered to be equal in quality to the imported—a certificate H. M.

No. 273, by J. R. Ashford, of Philadelphia, six dozen of kid gloves, of a quality similar to the last mentioned—a certificate H. M.

The judges also mention with commendation No. 1, a case of silk stocks, by C. A. Walborn; No. 6, a case of raw sewing silks, by Mrs. Waples, of Sussex county, Delaware, the production of a private family; No. 907, silk suspenders, by Solomon Dœbely, of Philadelphia; No. 11, a case of satin stocks, by S. A. Sendos, of Philadelphia, some of the stocks being made of American silk; No. 97, one case of silk goods, which compare favorably with the Chinese article of the same kind, by Benjamin H. Hooley, of Philadelphia; No. 98, a lot of silk handkerchiefs printed in the United States, at the Thornton Print Works, deposited by Simpson & McGregor; No. 213, by George W. Ward, of Philadelphia, one case of fashionable stocks; No. 38, a case of stocks, by Mrs. A. J. Kneeland; No. 218, silk stocking, made and deposited by Amy Jones, of Camden, N. J.; and No. 353, by J. T. Whitecar & Co., of Philadelphia, one case of suspenders, chiefly of silk and gum elastic, and parts of which are lined with canvas.

### V.—*Iron and Steel.*

The samples of Iron and Steel, submitted at the exhibition, have been carefully examined by the judges, have stood their tests well, and afford gratifying proofs of the progress of this important branch of manufacture. The judges recommend the following awards, which are accordingly made by the committee:—

No. 1705, by Savery & Co., of Philadelphia, specimens of hollow-ware, and other castings of great excellence—a certif. H. M.

Nos. 1649 to 1651, deposited by Morris & Jones, of Philadelphia, an excellent collection of specimens of iron, in different stages of manufacture—a certif. H. M.

No. 1625, by J. L. Mott, of New York, a cast-iron bathing tub, of good form and size—a certif. H. M.

No. 1599, by John Robbins, jr., of Kensington, blistered steel, made from Swedish iron—a certif. H. M.

The judges speak favorably of the specimens of Round and Flat Iron, from the Colemanville Iron Works; of some of the hammered iron from William Dowling, of Mary Ann Forge, Chester county; of the nail rods from the Colemanville Works, deposited by Morris & Jones; of those from Valentine & Thomas, deposited by Isaac Miller; and from the Howard Iron Works, deposited by E. J. Etting & Brother.

The Imitation Russia Sheet-iron, by James Wood & Sons, maintains the high character which induced the Institute to award to it a silver medal at the last exhibition. The attempt of Mr. Thomas Speakman, of Philadelphia, to imitate the Russia iron, is mentioned as worthy of encouragement. The sheets of Boiler Iron, deposited by William F. Potts, and made by S. Hatfield, also those deposited by Morris & Jones, are commended by the judges.

The report of the judges will be published in full.

### VI.—*Umbrellas, Etc.*

The display of Umbrellas, Parasols, and Sun Shades, was creditable to the manufacturers. In accordance with the tenor of the observations of the judges, the committee awards:—

No. 268, by Messrs. W. & W. H. Richardson, of Philadelphia, for an assortment of parasols and sun shades, a new pattern—a certif. H. M.

No. 247, by W. A. Drown, of Philadelphia, for an assortment of parasols and sun shades—a certif. H. M.

### VII.—*Lamps and Gas Fixtures.*

The display of these articles has never been surpassed in beauty at any former exhibition. The judges devote a considerable portion of their report to a notice of the beautiful articles which formed the greater, as well as the most admired, part of this collection, produced by Cornelius & Co. The richly ornamented gas pendants in ormoulu, and the silvered chandeliers and candelabra are particularly referred to, as well as the solar and lard lamps from the same manufactory. This report will hereafter be published; the committee now awards in accordance with its recommendation:

Nos. 1235 to 1242, by Cornelius & Co., of Philadelphia, a rich display of chandeliers, candelabra and lamps, the forms of which were truly beautiful—a silver medal.

No. 728, by E. Whelan, of Philadelphia, a pair of silvered candelabra—a certif. H. M.

No. 1257, by J. S. Gold, of Philadelphia, an assortment of camphine lamps and chandeliers—a certif. H. M.

No. 1372, by Ellis S. Archer, of Philadelphia, various lard lamps—a certif. H. M.

No. 656, by Filley & Kisterbock, of Philadelphia, for various lard lamps—a certif. H. M.

### VIII.—*Hardware and Cutlery.*

Notwithstanding the number and variety of the articles exhibited in this line, they appear to have received close and careful examination. The Committee of Judges, as in so many other cases, regrets that many specimens were brought to the exhibition too late to come under their notice.

The judges recommend, and the committee sanctions, the following awards:—

R. & W. Robinson, of Attleboro', Mass., for No. 634, deposited by Colladay & Brother, one case of gilt metal buttons, of exquisite finish—a silver medal.

Ibbotson & Horner, of New York city, for No. 725, deposited by Savery & Co., one box of horse rasps, and three square files, of excellent material and workmanship, eighteen dozen of three square files, of assorted sizes, being exhibited—a silver medal.

The following named articles, which received premiums at the last exhibition, are spoken of as fully sustaining the character then acquired:—The wire cloth, No. 620, by J. Mecredy, of Philadelphia; the files and rasps, No. 621, by G. Machin, of Philadelphia; the pocket and pen knives, No. 633, by Bradley & Beecher, of Naugatuck, Conn., deposited by Heaton & Denckla; the screws, No. 682, made by the New England Screw Company, Providence, R. I., and deposited by Curtis & Hand.

The following awards, recommended by the judges, are also confirmed.

Wadhams, Webster & Co., of Wolcottville, Connecticut, No. 616, a case of gilt buttons, beautifully finished—a certif. H. M.

H. Huber, jr., Philadelphia, for No. 644, one case of saddlers' tools, highly commended by the judges—a certif. H. M.

W. Reed & Co., of Philadelphia, for No. 675, one card of brass cocks, of superior workmanship—a certif. H. M.

No. 1705, Savery & Co., of Philadelphia, for butt hinges and sad irons, of an admirable quality and appropriate finish; the butt hinges being considered the best exhibited—a certif. H. M.

A number of specimens of butt hinges were presented for competition, and the judges speak favorably of No. 661, a card of cast-iron butt hinges, by J. L. Johnson, of Philadelphia, deposited by Steinmetz & Justice; of No. 662, a similar article, by Thomas Loring, of Philadelphia, deposited by W. Hart Carr; of No. 701, the same article, by Stewart, Biddle, Lloyd & Co., of Danville, Penn., deposited by W. P. Cresson & Brother.

Special notice is taken of No. 694, one case of saws, and one circular saw, by J. Wood & Sons, of Philadelphia; of No. 703, locks of a peculiar construction for mortise door locks, by T. L. Littlefield, of Philadelphia.

This latter article should be referred for examination to the Committee of Science and the Arts.

The following articles are also noticed with approbation by the judges:—

No. 627, six pair of iron chains, made by J. & E. M. Smith, of Hamburg, Pa., and deposited by Shipley & Warner.

No. 629, well finished coopers' tools, by Barton & Smith, of Rochester, N. Y.

No. 645, five rifles, by John Krider, of Philadelphia, deposited by J. T. Siner, fully sustaining the reputation of the maker.

No. 659, planes made by David Colton, of Philadelphia, the best specimens exhibited.

No. 663, iron and tinned iron rivets, by Holmes, Edes & Co., of North Marshfield, Massachusetts, deposited by Heaton & Denckla.

No. 712, a well made rifle and appliances, by T. T. Subers, of Philadelphia.

No. 715, four scythes, by O. Hunt & Brother, of Stavesville, deposited by Heaton and Denckla.

No. 716, six scythes, by Inman & Co., of Slatersville, Pa., deposited by Heaton & Denckla.

The judges remark that the home manufactured scythes have entirely superseded the use of the imported articles.

The articles of Britannia Ware are thought by the judges to give earnest of improvement; they particularly mention No. 654, by J. H. Palethorp & Co., of Philadelphia, and No. 657, by Boardman & Hall, of Philadelphia.

The excellent locks of Prutzman came too late for competition.

### IX.—*Saddlery, Harness, and Trunks.*

The judges are of opinion that there should have been a greater variety in the articles in this department, to have given a fair representation of the condition of the art. The articles deposited were, however, generally of a good quality. In conformity with what is understood to be the recommendation of the judges in the report, the committee awards:—

No. 328, by James E. Brown, of Philadelphia, well made trunks—a certif. H. M.

No. 380, by Jacob Moyer, of Philadelphia, a beautiful traveling trunk—a certif. H. M.

No. 366, by E. P. Moyer, of Philadelphia, a well made trunk—a certif. H. M.

No. 352, by John Unruh, of Philadelphia, a traveling trunk with white nails, beautifully finished—a certif. H. M.

The harness by Lacy, sustains, in the opinion of the judges, his high reputation. A leather trunk, by Adriance, No. 342, is spoken of with praise, also both specimens of medical bags, by S. F. Summers, No. 315, and by A. M. Martin, No. 389.

The assortment of Whips was good.

The Harness Ornaments, No. 362, of J. Welsh, of Philadelphia, deposited by S. R. Phillips, are worthy of notice.

### X.—*Models and Machinery.*

The collection of Models and Machinery was not such in quantity or variety as fairly to represent the condition of the Mechanic Arts, even in our city. There can be no doubt that our workshops have felt the influence of the depressing circumstances of the years just past, but there can also be no doubt that a much more creditable display might have been made, had our workmen felt more fully that their interest and reputation were at stake. Whole branches known to be in active operation were unrepresented by even a single machine. This is the more to be regretted that considerable expense was incurred to provide most ample accommodation for heavy machinery. It is true that many of the articles exhibited were highly creditable to the manufacturers, and that after the date at which, by the rules of the Institute, notice could be taken of specimens, many excellent articles were brought into the rooms, but still this department of the exhibition was not what it might have been. The committee submits to the Philadelphia mechanics whether this state of things is fair to the Institute, or to the public, and hopes that on another occasion this department will bear quite a different character.

The judges recommend, and the committee makes the following awards:—

No. 1538, by James & Joseph Albertson, of Philadelphia, a skiff, with an oak frame and cedar planking, of beautiful workmanship—a silver medal.

No. 1631, by Charles Evans, of Philadelphia, copying presses, of excellent workmanship—a silver medal.

No. 1503, by James Brooks, of Frankford, Pennsylvania, a horizontal steam engine, a good and serviceable piece of work—a certif. H. M.

No. 1504, by J. W. & J. F. Starr, of Kensington, a locomotive boiler, considered to be an excellent specimen of work—a certif. H. M.

No. 1530, by E. G. & R. O. Tripp, of Trenton, N. J., deposited by A. Quintin, of Bristol, Penn., a box of shuttles—a certif. H. M.

No. 1531, by J. D. Dale, of Lansingburg, N. Y., deposited by Gray & Bennett, of Philadelphia, four platform scales—a certif. H. M.

No. 1577, by Stephen Ustick, of Philadelphia, a log brace for saw mills—a certif. H. M.

No. 1582, by Jacob Lodge, of Philadelphia, an apparatus for corking bottles to contain effervescing waters—a certif. H. M.

No. 1583, by D. O. Prouty & Co., of Philadelphia, a sub-soil plough —a certif. H. M.

No. 1626, by Jordan L. Mott, of New York, a stationary cowl, or ventilator, shown by the experiments of Mr. Ewbank, to answer its purpose well—a certif. H. M.

No. 1617, by David Evans, Philadelphia, a fire proof chest, water coolers and filters—a certif. H. M.

No. 1618, by John McConn, of Philadelphia, deposited by Carter & Parham, hatters' heating irons—a certif. H. M.

No. 1619, by George Snyder, Philadelphia, for well shaped, smooth, and dense bricks—a certif. H. M.

No. 1654, by G. W. Metz, Philadelphia, for a well made blacksmith's bellows, with a new mode of inserting the pipe—a certif. H. M.

No. 1661, by Joseph Laubach, deposited by John Murphy, a patent blacksmith's tuyere, furnishing an efficient blast from the bottom of the fire—a certif. H. M.

No. 1665, by William Elliott, Francisville, near Philadelphia, a model of a hipped roof, slated with specimens of different kinds of work of excellent finish—a certif. H. M.

No. 1689, by Greer, Amer & Newell, Philadelphia, a small steam engine, well contrived and executed—a certif. H. M.

The lathe of John H. Schrader, reported by the judges for a certificate, was too late for competition.

To Gideon Cox, Philadelphia, for the deposit of various specimens of wooden ware for household use—a certif. H. M.

To Landreth & Munns, Philadelphia, for an exhibition of agricultural implements and tools—a certif. H. M.

To D. O. Prouty, Philadelphia, for an exhibition of similar articles —a certif. H. M.

To Edwin Chandler, Philadelphia, for a similar display of implements—a certif. H. M.

To James Young, Philadelphia, patent agent for a number of ingenious machines, deposited by him—a certif. H. M.

The utility of establishments like these, where agricultural and other implements and machines for various purposes may be found by purchasers, who often require advice in regard to their choice and use, induces the committee cheerfully to make awards to these gentlemen for the variety of specimens deposited by them.

The judges are of opinion that the self-adjusting counter spring, by Oliver Evans, of Philadelphia, and Cottrell's lattice weighted bridge, should be presented by their inventors for the examination of the Committee of Science and the Arts.

The minute report on this department will be hereafter published; it closes with a regret that many articles of value were deposited too late for competition, or notice.

The judges speak approvingly of No. 1570, by J. Dutton, Delaware county, an apparatus for distributing water in thin sheets, to promote its freezing; of No. 1596, by George W. Duncan, Philadelphia, an abridged set of stencil plates for marking; of No. 1598, by William M. Davis, Philadelphia, a small lathe of good workmanship; No. 1634, by Ellis Jackson, Philadelphia, well made shuttles for weavers; No. 1640, by Jacob Senneff, Philadelphia, a power loom shuttle, of neat workmanship; No. 1702, by Mahlon Gregg, Philadelphia, a machine for cutting tenons.

## XI.—*Stoves, Grates, Etc.*

The spirited competition which exists in these important articles, always secures an excellent display of them at our exhibitions. On the present occasion the means of exhibiting practically the good qualities of the Stoves and Ranges, were as ample as could possibly be desired. The detailed report of the Committee of Judges will be published in the Journal of the Franklin Institute, thus furnishing more minute information in regard to the several articles exhibited, than can be given in the compass of this report.

Upon the recommendation of the judges, the following awards are made :—

No. 1501, by Pleis, Fœring & Thudium, Philadelphia, for a radiator stove—a certif. H. M.

No. 1620, by Jacob F. Pleis, Philadelphia, for a radiator stove—a certif. H. M.

No. 1707, by Weaver & Volkmar, Philadelphia, for a radiator stove—a certif. H. M.

No. 1720, by Williams & Hines, Philadelphia, for a radiator stove —a certif. H. M.

No. 1714, by J. W. Kirk, Philadelphia, deposited by Williams & Hines, for a crescent radiator, of new and curious arrangement—a certif. H. M.

No. 1721, by A. Brenizer, Philadelphia, for an air-tight stove, for wood—a certif. H. M.

The Ornamental Stoves, as well as the Cooking Stoves and Ranges, resembled very much those exhibited during the two years last past.

Farther awards are made, on the recommendation of the judges.

No. 1608, a cooking stove, by S. R. Sank, deposited by T. Durell —a certif. H. M.

No. 1698, a cooking stove, by J. Kisterbock—a certif. H. M.

No. 1686, a summer stove and baker, by M. Stewart—a certif. H. M.

No. 1528, by Lloyd & Feltwell, Philadelphia, a cooking range—a certif. H. M.

No. 1557, by Julius Fink, Philadelphia, a cooking range—a certif. H. M.

The two ranges just named have taken a premium at former exhibitions, and can, therefore, now, according to rule, have no other testimonial than the certificate, which shows them so far to be in the first rank.

No. 1534, a cooking range, by F. McIlvaine, Philadelphia—a certificate H. M.

No. 1567, a cooking range, by Henry Hallman, Philadelphia—a certif. H. M.

To Jordan L. Mott, New York, for the extensive and creditable display of stoves, furnaces, boilers, &c., deposited by De Witt C. Mott —a certif. H. M.

No. 1559, by C. W. Warnick, Philadelphia, for a similar exhibition —a certif. H. M.

## XII.—*Cabinet Ware.*

The specimens of Cabinet Ware exhibited this year, fully sustained the reputation of our manufacturers, which is deservedly very high; it was, however, a subject of remark that on an occasion where so excellent an opportunity for the display of a large number of articles had been provided, by furnishing ample space for exhibition, the number fell short of those of the exhibition of last year. In the opinion of the judges, many of the articles exhibited were beautiful models of taste, ingenuity, and excellent construction, challenging competition, especially in the last named quality.

The committee makes the following awards, recommended by the judges:—

Nos. 1319 to 1321, by J. & A. Crout, Philadelphia, a centre table, and other articles of American woods—a silver medal.

The committee particularly recommend this branch of art to the fostering care of the Institute, and are of opinion that the specimens just named are not excelled by the productions of the like sort in any country, in regard to which they have had full opportunities of being informed.

Nos. 1330 to 1332, by Charles H. & J. F. White, Philadelphia, articles of furniture in the Gothic style, of excellent workmanship, and tasteful design—a silver medal.

Nos. 1222 to 1225, by Alphonse Quantin, Philadelphia, deposited by A. Lejambre, furniture in the style of Louis XVI, (renaissance) of rich materials and good workmanship—a certif. H. M.

No. 1293, By Benjamin J. Williams, Philadelphia, Venetian blinds, of good construction and excellent finish—a certif. H. M.

The specimens of painting in wood, by John Gibson, exhibited in numerous articles, were much admired. The committee awards a certificate of H. M.

## XIII.—*Musical Instruments.*

Superior facilities were afforded this year for the exhibition of Musical Instruments, and the number and variety were considerable. The judges are of opinion that most satisfactory proof was afforded of progress in this branch of art. The elaborate report of the judges will be published in the Journal of the Institute. The Committee on Exhibitions having maturely weighed the subject, and compared the principles which govern the award of the honors of the Institute in other departments, with those laid down by the judges, in reference to their recommendations in this, are constrained to raise the grade of award to different competitors, while the comparative scale presented by the judges is strictly adhered to. The committee, therefore, awards:

No. 209, A, by Messrs. Gale & Co., New York, deposited by J. C. Smith, a piano, considered by the judges to be one of the two best of its kind in the exhibition—a silver medal.

No. 1271, by Conrad Meyer, Philadelphia, a piano, deemed by the judges to be one of the two best of the kind in the exhibition—a silver medal.

The only grand piano exhibited was from the manufactory of Thomas Loud, Philadelphia, but so many excellencies were found in it by the judges, that the committee does not hesitate to award to No. 1302, by Thomas Loud, Philadelphia, a grand piano, combining various excellencies of construction—a certif. H. M.

The committee further awards to,

No. 1346, by C. F. Martin, Nazareth, Pa., deposited by F. Peale, a Spanish Guitar, of graceful proportions, and very fine tone—a certificate H. M.

The judges speak with praise of the seraphina, No. 1178, by Chris. Knaurr, and the case of wind instruments, No. 1266, by Thomas W. Weygandt; of the pianos of the Philadelphia Manufacturing Company, Messrs. Groves, Loud, Miller, Reichenbach, and Betts.

The committee also awards to

No. 1201, a parlor organ, by Henry Corrie, deposited by James Cox, novel in some of the arrangements, and of good tone—a certif. H. M.

The parlor organ, No. —, by Joseph Buffington, deserves notice as the highly creditable work of a self-taught young man, who has devised and executed every part of it without assistance, or other instruction than he could derive from books, and the occasional conversation of a friend.

### XIV.—*Glass and China.*

The display in this department was not equal to that at the last exhibition, nor did it do justice, much less credit, to the sate of the manufacture in the country. The judges very justly remark that "Philadelphia furnishes a market for a large amount of Glass Ware, and the manufacturers of the article would certainly have advanced their interests had they submitted to the public, through the exhibition, a better variety of what they were capable of producing in their respective factories." In pursuance of the recommendation of the judges, the committee awards:

No. 601, made by P. C. Dummer & Co., of Jersey City, deposited by E. E. Smith, a cut glass bowl, of graceful form and good finish. and of a superior quality of material—a silver medal.

No. 713, by the New England Glass Company, Boston, deposited by S. D. Hastings, several pairs of cut glass salts—a certif. H. M.

No. 614, made by T. Richards, Philadelphia, samples of window glass, of pure material, and free from waves—a certif. H. M.

The judges speak in terms of high praise of No. 646, samples of pottery from the manufactory of Abraham Miller; but as Mr. Miller is one of the Board of Managers of the Institute, the rules forbid any award in this case. They also commend No. 722, specimens from the American Pottery Company, Jersey City. The Committee of Exhibitions refers to the report of the judges, which will be published hereafter, for excellent remarks in reference to this useful branch of manufacture.

No. 652, a cut glass decanter, with nine compartments, was much admired.

## XV.—*Books and Stationary.*

The display in this department has fallen off at the last two exhibitions; a wrong done by manufacturers to themselves, as well as to the public. The judges have not recommended any special awards, but from the terms of their report the committee awards:

No. 180, by S. Moore, Philadelphia, deposited by Carey & Hart, books in a great variety of bindings, remarkable for neatness of execution, and good taste—a certif. H. M.

The case in the Gothic style, in which these books were contained, by J. Blair, the painting by Gibson, was much admired.

No. 1289, a map of the United States, by Mitchell, the smaller size, done on wood and stereotyped—a certif. H. M.

The judges speak in commendation of No. 19, a map of the United States, by Sherman & Smith; No. 210, well made slates, from Samuel Taylor, Easton, Pa.; No. 1550, slate pencils, of admirable material, but too roughlyfinished; No. 1203, a map of Philadelphia county, by J. H. Young; No. 212, deposited by J. B. Lippincott & Co., American elastic inkstands, of various sizes; No. 254, wood type, for fancy work, by Wells & Webb, New York; No. 26, by Lindsay & Blakiston, a number of beautifully bound books.

The committee coincide entirely with the judges in their expression of disapprobation, in regard to the foreign stamps and names put by some of our manufacturers upon their goods.

## XVI.—*Paper Hangings.*

At the last two exhibitions, this department attracted much of the attention of visiters, from the number and excellence of the specimens. The results to the manufacturers were immediate. On the present occasion the specimens show that there has not been a falling off in the quality of the articles, but the quantity was too small to excite attention. This is the more to be regretted when the present rooms offer so excellent an opportunity for the display of wall papers. The committee hope that the public may be more respectfully considered on a future occasion.

## XVII.—*Fine Arts.*

The subjects more particularly appropriate to an exhibition like ours, are not those which constitute the most attractive parts of a picture, or statue, gallery. It is difficult, however, to draw the line between the appropriate and inappropriate, and when artists of merit, in the higher walks of the fine arts, submit their productions to the public through the medium of our exhibitions, it is right to acknowledge their sense of their merits. The committee awards as follows:

No. 1221, by G. W. Conarroe, Philadelphia, a portrait of the Hon. Calvin Blythe, and a portrait of a lady—a certif. H. M.

No. 1215, by W. Warner, Philadelphia, a collection of mezzotint engravings—a certif. H. M.

The "Arm Chair," a picture by Mr. Warner, referred to by the judges, was too late for notice.

Nos. 1279, 1280, and 1294, portraits in water colors, by M. S. Parker—a certif. H. M.

The judges speak in terms of praise of the design for a monument, and for a fountain, by J. C. Trautwine, and of the water color drawings, by Wm. Mason, and of the wood engravings generally.

The committee award No. 1267, by C. B. Ives, Philadelphia, for a marble bust—a certif. H. M.

The committee notice with commendation the collection of Daguerreotype miniatures, No. 1317, by J. Plumbe, jr.

The splendid full length picture of Henry Clay, for which the exhibition was indebted to Mr. Neagle, was deposited too late to be noticed by the judges.

## XVIII.—*Silver Ware and Jewelry.*

The number of articles of Silver Ware exhibited this year was considerable, and their finish admirable. The exhibition of Jewelry, on the contrary, was smaller. The judges recommend the following awards, which are made accordingly:

No. 642, by Messrs. R. & W. Wilson, Philadelphia, containing two plain tea-pots, and a pair of oyster dishes, particularly noticed as showing good hammering and fitting—a certif. H. M.

The judges refer particularly to a pitcher of chased work, No. 608, by Bard & Lamont, commending the mechanical execution, while they disapprove of the design. They are of opinion, that, in general, in this branch, purity of design, and perfection of form, are not sufficiently studied. Without these, exquisite polish, and beautiful chasing serve but to cover defects which they cannot hide.

## XIX.—*Bookbinders' Tools.*

The competition in this branch is always very limited, from the intrinsic circumstances of the art itself. The specimens at this exhibition fully sustain the high reputation of those depositors whose specimens came in time to be examined by the judges, under the published rules of the exhibition.

The judges mention especially the brass tools of Messrs. Gaskill & Copper; a steel embossing plate, by A. C. Morin; the designs by Chapman, Persell & Thompson, of New York, and the steel plates for engravers, by the same firm.

## XX.—*Marble Work.*

There were so few articles in this line in the exhibition as to produce general surprise; the meagre collection not corresponding to the known variety of Philadelphia marble work.

The judges speak favorably of, and the committee awards a certificate of honorable mention to No. 1292, a mural tablet, by Ferd. H. Strecker.

## XXI.—*Hats and Caps.*

The display in this department was admirable indeed, far surpassing even that in 1840, when there was so much competition among the makers and finishers of these articles. The judges have performed their duty in a way not to be surpassed, but find excellence so general, that after their minute examination they are at a loss to recommend awards which shall place one competitor above another. Their minute and well prepared report will be published for the information of all concerned, and the committee hopes that the hints given in it will not be lost upon manufacturers in this line. The committee regrets that they cannot comply with the wishes of the judges in regard to articles deposited after 12 o'clock on Tuesday last, even under the very strong circumstances which they present: the rule must be absolute, or it must give rise to exceptions which no impartiality, or sagacity, on the part of the Committee of Exhibitions could meet.

In accordance with the explicit recommendations of the judges, the committee awards:

No. 976, by Orlando Fish, New York, deposited by C. A. Walborn, three nutria and three moleskin hats—a certif. H. M.

No. 997, by John C. Yeager, Philadelphia, hats of "neat appearance, excellent color, and moderate prices"—a certif. H. M.

No. 1072, by E. Kimber, jr., Philadelphia, a case of hats, two fur bonnets, and a fancy hat for a child—a certif. H. M.

Special praise is given by the judges to the following named among the depositors whose goods were in the hall in due time:—to John Hill, Philadelphia, for a nutria and a moleskin hat, of good finish and color, and very light; to Mrs. Hill, Philadelphia, for two children's caps; to Oliver Brooks, Philadelphia, especially for his cassimere hats; to Messrs. Lamberti & Blynn, for a case of hats, distinguished for neatness of style.

The beautiful case of hats, by Charles Bulkley, was too late for competition.

The judges trace the improvement in this branch of manufacture to the competition in trade, and particularly to the stimulus afforded by the exhibitions of the Franklin Institute. Those who do not succeed in obtaining praise at one exhibition, have but to make the requisite improvement to attain this result the following year, and all have an opportunity to exhibit their goods to thousands of examiners who may become purchasers.

### XXII.—*Combs and Brushes.*

The competition in these articles was very small, and the judges do not recommend any special awards.

### XXIII.—*Coach Work.*

The specimens in this branch of art were very beautiful. Many were remarkable for taste of model and coloring, and for ingenuity of construction, combining strength with lightness. The judges specially commend the following articles, to which awards are made:

No. 1593, by Joseph Glenat, an omnibus for thirty passengers, sixteen feet long, of superior workmanship, and admirably contrived for the purpose of a pleasure omnibus—a silver medal.

No. 1565, by A. Knowles, Philadelphia, deposited by the maker, the best York wagon in the exhibition—a silver medal.

The judges speak with commendation of the workmanship of No. 1551, by George Jeffries, and of No. 1552, by Ogle & Watson, both Rockaway wagons; of No. 1553, a coach, by Ogle & Watson; of No. 1653, a York wagon, by Vansciver & Sons; of the construction of No. 1555, a bow spring carriage, by A. Merritt, Philadelphia.

They also approve of No. 1541, patent harness, by L. Houghton, Boston, deposited by J. Young; of No. 1680, turned spokes, by S. Bedford, Newark, N. J., deposited by H. & J. Fricke; of No. 1681, hardened taper axles, deposited by H. & J. Frick; of No. 1691, taper coach axles and tight boxes, by Greer, Amer & Newell.

## XXIV.—*Leather and Morocco.*

The judges speak in terms of high commendation of the exhibition in this department. Where so much excellence exists, it is diffiult to determine between the claims of the several artisans, but the beautiful display which has been brought forward, deserves to be marked by a generous notice. The committee accordingly make the following awards:

Nos. 302 to 304, by Fritz & Williams, Philadelphia, specimens of Morocco—a certif. H. M.

No. 318, by Charles B. Williams, Philadelphia, sides of sole leather —a certif. H. M.

No. 386, by the Boston Manufacturing Company, deposited by John W. Patton, Philadelphia, specimens of patent leather, of beautiful finish—a certif. H. M.

No. 391, by Taylor & Kinsey, Philadelphia, for half a dozen of Madras French Morocco—a certif. H. M.

No. 399, by Scattergood & Boustead, Philadelphia, for six sides of Russet bridle leather—a certif. H. M.

The following articles are noticed with special commendation. No. 321, one chaise hide, by C. & W. Pyle & Co., Wilmington, Del., deposited by J. L. Webb; No. 329, two sides of slaughter sole leather, by John W. Patton, Philadelphia; No. 371, one side of enameled top hide, by J. & R. Ward, of Newark, N. J., deposited by Thomas Mogridge; No. 384, eight calf skins, by C. & A. Dannaker, Philadelphia; No. 392, one goat skin, and one buck skin, by John Ebert & Son, Frederick, Md., deposited by C. A. Walborn; No. 397, two bag-hides, by Scattergood & Boustead; No. 398, six hides of ladies' dressed sole leather, by Scattergood & Boustead, Philadelphia; No. 401, parchment and morocco, by Doyle & McNeeley, Philadelphia; and No. 402, a lot of leather, by Fidel Fisher, Philadelphia.

The number and excellence of the articles now submitted, fully make up for the meagre display upon which the Committee on Exhibitions of last year felt it to be their duty to comment.

## XXV.—*Boots and Shoes.*

The report of the judges is very specific in regard to the awards, and the committee makes them in accordance with it.

No. 375, deposited by William Moyn, Philadelphia, and consisting of gentlemen's boots and slippers, articles combining usefulness, durability, comfort, and good taste—a silver medal.

No. 357, deposited by John Ryan, a case of fancy boots, displaying good workmanship—a certif. H. M.

## XXVI.—*Chemicals, &c.*

The display of Chemical preparations, and of articles submitted with them to the examination of the judges, was highly creditable, superior, in fact, in number and variety of articles to the collection of any former year. The judges have made a very full report, which will be published for the satisfaction of the depositors, and the information of the public.

The judges recommend, and the committee makes the following awards:

No. 309, by Messrs. Wetherill & Brothers, Philadelphia, for a suit of chemical preparations, of great excellence—a certif. H. M.

No. 335, by Messrs. Smith & Hodgson, for the general excellence of the specimens—a certif. H. M.

No. 327, by Lawrence Turnbull, Philadelphia, deposited by Frederick Brown, for the general excellence of the articles—a certif. H. M.

No. 613, by Edward Parrish, Philadelphia, a case of Pharmaceutical preparations, designed for the use of students of medicine—a certif. H. M.

No. 635, by Stephen Heintz, Malaga, N. J., deposited by L. Voigt, a lot of chemical glassware, of approved forms and quality—a certif. H. M.

No. 306 to 308, by Lovering & Co., Philadelphia, loaves and jars of sugar, refined without the use of blood—a certif. H. M.

No. 373, by Charles W. Gschwind, Philadelphia, for beautiful specimens of glue—a certif. H. M.

No. 388, by Hancock & Mann, Baltimore, deposited by White, Warner & Co., for beautiful specimens of their "adamantine candles" a certif. H. M.

No. 351, by Campbell Morfit, Philadelphia, a series of specimens exhibiting the process of manufacture of candles from stearine without saponification—a certif. H. M.

The judges speak in terms of high commendation of the industry shown by Mr. Morfit, in perfecting this important branch of manufacture.

No. 338, by Eugene Roussel, Philadelphia, an admirable exhibition of fancy soaps and perfumery—a certif. H. M.

The judges speak in terms of praise of the chemicals submitted by Messrs. Harrison & Brother; of the acetate of lead, from Mordecai Lewis; of the cyanide of potassium, from H. W. Worthington; of the isinglass, from C. Delacour. Also of the fancy soaps, by Curtis Taylor & Son, and the perfumery, by N. B. Hinton, and by Jules Hauel.

No. 382, by Gerhard Schmitz, Philadelphia, for specimens of chocolate—a certif. H. M.

### XXVII.—*Philosophical Apparatus.*

The display in this department was unusually creditable to the depositors, though the number of those depositing was smaller than on former occasions. The following awards, recommended by the judges, are made by the committee:

No. —, a four feet transit circle, by W. J. Young, Philadelphia, of beautiful workmanship—a certif. H. M.

No. 688, &c., by J. Bishop, Philadelphia, two electrical machines, and other apparatus—a certif. H. M.

No. 709, by James Duffey, Philadelphia, balances for hydrostatic and other purposes—a certif. H. M.

No. 1335, dew point and wet bulb hygrometers and magnetic instruments, by Solon W. Hall, Philadelphia—a certif. H. M.

No. 186, a globe and planispheres, with geographical, &c. lines, for instruction in geography and astronomy, by the Rev. R. Piggot, Maryland—a certif. H. M.

The judges mention with approval No. 708, models of machines, by James Duffey, jr., Philadelphia; No. 360, shades for magic lanterns, by Thomas A. Nolens, Rochester, N. Y.; and No. 700, the dial of the seasons, by Thomas Fisher, Philadelphia.

The neglect of Mathematical and Philosophical Instrument makers to show to the many strangers and citizens who attend our exhibitions, specimens of their handiwork, is commented upon by the judges, with whom the committee fully agree as to the bad policy of the course.

### XXVIII.—*Straw Goods.*

The report of the judges upon these articles will be published hereafter. The committee confines itself to making the awards indicated by the judges:

No. 214, by A. Caseli, New York, specimens of Amazon braid, "purely white, even in texture," and of good quality—a certif. H. M.

The judges notice also with approval, No. 215, Amazon braid bonnets, by S. D. Hall & Co., New York.

Some of the best articles in this department came too late for competition.

### XXIX.—*Surgical Instruments.*

The articles classed under this head have been examined with great care. In conformity with the report of the judges, the committee awards as follows:

No. 707, by M. S. Foster, Trenton, N. J., a set of porcelain teeth, of unusual excellence—a silver medal.

No. 697, by Henry Habermehl, Philadelphia, an artificial hand and legs—a certif. H. M.

No award can be made for No. 672, an abdominal supporter, by Messrs. Wiegand & Snowdon, as Mr. W. is a member of the Board of Managers of the Institute.

No. 660, by Horatio G. Kern, Philadelphia, a case of instruments, chiefly dental—a certif. H. M.

### XXX.—*Gum Elastic Goods.*

There was no competition in these articles generally, but the judges were much struck with the perfection of the articles exhibited by Mr. Thornley, and recommend the following award, which the committee makes:

No. 332, by J. Thornley, Philadelphia, India rubber goods, of admirable quality—a certif. H. M.

The judges speak particularly of the gum elastic over shoes with leather soles, with gum elastic shanks to leather soles; of the gum elastic air mattrasses, and cloth for signs, all contained in the lot just mentioned.

They praise also the shoes, with gum elastic soles, made by John S. Ripley, Philadelphia.

### XXXI.—*Copper, Brass, and Plumbers' Work.*

The assortment under this head was small. The judges mention No. 1529, seven specimens of copper and brass ware, by W. B. Bentley, Philadelphia, as deserving commendation; also No. 1536, a lot of braziers' solder, by William Kent, Philadelphia, as of good color and well grained.

They refer in terms of high commendation to the lead pipe, made by Messrs. Tathem & Brothers, Philadelphia, which has already received a medal from the Institute.

### XXXII.—*Tin Work.*

The judges report that there was nothing worthy of special attention in this line deposited in the exhibition.

### XXXIII.—*Paints and Colors.*

The decisions in reference to relative merit in this department, are difficult to make in the short time allowed by an exhibition. The judges have applied such practical tests as the time permitted, and speak with praise of the following articles:

No. 309, by Wetherill & Brothers, of chrome yellow, of excellent color; No. 409, chrome green, by C. J. Crease; No. 343, red lead and orange mineral, of superior fire, by George Uhler; No. 355, coach varnish, by Wm. M. Humes; No. 325, Osborne's water colors, deposited by Smith & Hodgson; No. 364, rose pink, of superior color, by Charles Hasse.

No. 334, lamp black, by Wainwright & Elliott. The uncalcined lamp black is pronounced to be rather superior, and the calcined, very superior to the English article—a certif. H. M.

The white lead exhibited was of a superior quality; the judges mention particularly a specimen by Wetherill & Brothers, which they recommend to the attention of artists.

The committee awards to No. 309, by Wetherill & Brothers, the smaller samples of white lead, which may, in the opinion of the judges, supersede the Kremnitz white—a certif. H. M.

## XXXIV.—*Fancy Articles.*

This department, as usual, presents articles of very different grades of merit. The judges state that they have examined all carefully, and report those which they consider best worthy of notice. Awards are made to the following named articles:

No. 901, by Thomas B. Smith, Philadelphia, an admirable assortment of pickles, of various kinds—a silver medal.

No. 945, by A. Rudduck, deposited by J. M. Bolton, one case of pearl work, the carving upon which is deemed of excellent quality—a certif. H. M.

No. 951, by Philip Dolflien, Philadelphia, a miniature equestrian statue of Napoleon, in bronze—a certif. H. M.

No. 961, by Sarah Bringhurst, Philadelphia, a knitted bonnet and shawl—a certif. H. M.

No. 999 by W. H. Schreiner, two cases of artificial bait, consisting of flies, "grey hackle," and shrimps, considered by the judges as equal to the English—a certif. H. M.

No. 1009, by J. Doughty, for excellent preserves—a certif. H. M.

No. 1020, by Thomas Bogue, a gossamer wig ,weighing only one ounce, and of admirable finish—a certif. H. M.

No. 182, by C. A. Walborn, a beautiful specimen of corded collars —a certif. H. M.

No. 266, by Mrs. Wright, a linen shirt, the work upon which was much admired—a certif. H. M.

No. 1065, by Miss Johnson, Philadelphia, a splendidly embossed velvet bonnet—a certif. H. M.

No. 1077, by Joseph Sholl, an apiary, of ingenious construction—a certif. H. M.

No. 982, by James Keefe, Philadelphia, three boxes of vermicelli and maccaroni, of excellent quality, the only specimen ever exhibited —a certif. H. M.

No. 984, by Mrs. Ida Neher, Philadelphia, the best specimen of hair work on ivory—a certif. H. M.

The committee awards:

To the pupils of the Pennsylvania Institution for the Instruction of the Blind, for manufactures of tow cloth, rag carpet, rope and baskets —a certif. H. M.

The judges mention with approbation a number of articles.

No. 980, a beautiful specimen of worsted work, by Miss Seeger.

No. 1025, a similar, of raised worsted work, by Mrs. C. R. Fling; No. 1042, a frame of needle work, by Miss Prettyman; No. 985, a wreath and ottoman, by Miss A. Supplee.

The soda water of Eugene Roussel, with the peculiar fastening of the corks to present the escape of gas, fully sustains the high reputation of the article.

Notice is also taken by the committee of
No. 12, a case of ready made linen, by Mrs. S. Sendos.
" 167, " " " P. Chapouty.
" 187, " " " G. W. Ward.
No. 1028, a case of pearl work, B. & A. Waiter.

The committee further awards to

No. 651, by Capewell & Brother, for excellent specimens of sweet chocolate—a certif. H. M.

In conclusion, the committee returns thanks to the judges generally for their promptness in examining and reporting upon the departments confided to them. An unusual number of these reports are prepared with a care which renders them worthy of being presented to the public, and the committee will recommend them for insertion in the Journal of the Franklin Institute; thus, all defects which may be found in the present document will be remedied, and minute information be given in regard to articles, and departments of interest.

The certificates are ready for delivery, and the medals which have not been delivered may be had at the office of the Actuary.

To be Continued.

## Mechanics, Physics, and Chemistry.

### GLEANINGS FROM FOREIGN JOURNALS.—No. II.

*Proceedings of the Thirteenth Meeting of the British Association for the Advancement of Science.*[*]

*Catalogue of the Stars.*—Dr. Robinson, of Armagh, announced that the reductions necessary to form this catalogue were completed, and that it embraced the places of ten thousand stars, with the corrections necessary to determine their places at a subsequent epoch.[†]

*Action of the Chemical rays in Light upon Chlorine.*—Professor Draper, of New York, finds that chlorine gas which has been exposed to light, possesses qualities not found in chlorine made and kept in the dark. It unites rapidly with hydrogen. The chemical rays corresponding to the indigo in the spectrum, produce this effect in the greatest degree. The effect is permanent, and the light itself is deprived of the rays thus absorbed by the gas.

*On the heat of Combination.*—The following important law was developed, in a series of experiments, by Dr. Andrews, of Belfast:—"When one base displaces another from any of its neutral combinations, the heat evolved, or abstracted, is always the same when the base is the same; or, in other words, the change of temperature which occurs during the substitution of one base for another, in any neutral compound, depends wholly on the bases, and is, in no respect, influenced by the acid element of the combination."

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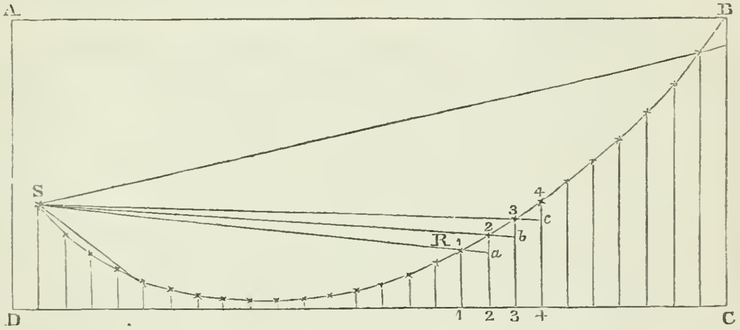
[*] This abstract of the principal proceedings of some of the sections of the British Association, is made from the report in the London Athenæum for August and September, 1843.

[†] Nearly ten thousand dollars were expended in the computation of this catalogue, and three thousand have been appropriated for its publication.

*Decomposition of Carbonic Acid under the light of the Sun.*—The decomposition of carbonic acid, and the alkaline carbonates, by the leaves of plants under the light of the sun, is found, by Professor Draper, of New York, to take place most rapidly in the yellow rays, the rays of highest illuminating power in the spectrum.*

*Form of Lecture Rooms.*—Mr. Scott Russell, of Edinburgh, describes the arrangement of a lecture room, the lecturer being placed in the focus of what he calls a curve of equal hearing, or isacoustic curve, and the heads of the hearers by the arrangement of the benches occupying points of the same curve. The arrangement is shown in the annexed diagram.



Let A, B, C, D, represent the vertical section of a building for public speaking; S, the height of the speaker on his platform; D, C, the floor of the building: then, for the purpose that all the auditors should hear and see equally well, they should be placed on the line, S, R, B, of the isacoustic curve. This curve is constructed in the following manner: D, C, is first divided into equal parts, to represent the usual breadth of a sitting, and vertical lines are drawn through these points. R, being the place of the auditor 1; the place of auditor 2 behind him, is assigned thus—join S, R, and produce it to *a*—from *a* upwards set off $a\ 2 = 9$ inches, and 2 is the proper height of the next spectator. Then join S 2, produce it to *b*, and set off $b\ 3 = 9$ inches, and 3 is the place of the third spectator; and so on for the place of every spectator. Such was the vertical section of the building. The horizontal section was either circular, or polygonal, having the speaker at the centre. This form had been found perfectly successful in affording the highest degree of comfort both to hearer and speaker.†

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* See also Bulletin of Amer. Philos. Soc. vol. iii, Centennary Meetings.

† This principle was applied, by Professor A. D. Bache, in the construction of two of the rooms in the building for the Collegiate Department of the University of Pennsylvania in 1830.

*Expenditure for the promotion of Science.*—The sum already appropriated to further the prosecution of original researches, calculations, for the publication of researches, &c., by the British Association, amounts to more than forty thousand dollars.

*Observations on the direction and force of Wind.*—Mr. Snow Harris deduces from the discussion of observations made at Plymouth with Whewell's anemometer, that there is, on the average, a general motion of the air from south to north. The observations with Osler's anemometer show a general tendency to two maxima, and two minima in the force of the wind during every twenty-four hours, the force increasing as the barometer falls, and *vice versa.*

*Tides of the eastern coast of Scotland.*—The result of simultaneous observations at twenty-one stations on the eastern coast of Scotland, were communicated by Mr. Scott Russell. At particular stations observations of the height of the tide were made every five minutes for one or more lunations. The general results in regard to the tide wave were as follows:

"As in the former observations of the Clyde and the Dee, it had been found in this series, that the form and dimensions of a channel produce important changes in the form of the tide wave. Where the sea was deep, and the shore open and abrupt, the form of the tide wave was symmetrical, and of the form predicted by Laplace, where he says, that in rising and falling, the water covers in equal times equal areas of a vertical circle. This is the form of the ocean tide wave; but, on approaching a shallow shore, and traveling along a shelving coast, the tide wave undergoes two changes—its summit becomes displaced forwards in time, its horizontal chords become dislocated, and the wave ceases to be symmetrical. This peculiar dislocation and displacement are characteristic of a littoral tide, and in the case of running streams, the currents still further affect the tide wave, and give to it a peculiar distortion characteristic of fluvial tides. To these were further added the exaggeration and elevation of the tide, by means of narrow channels. All these phenomena were fully proved by the present series of observations. The author of this paper also considers it to have been fully established by the observations on the Frith of Forth, that there exists on the eastern coast, satisfactory evidence of the presence of a second tide wave in that part of the German Ocean, and that the southern tide wave, a day older than the northern tide wave, sensibly affects the phenomena of that part of the coast: to this he attributes the double tides of the Frith of Forth."

*Destruction of Elasticity by small strains.*—Mr. Hodgkinson infers from his experiments, and those of Mr. Fairbairn, on different materials, including wrought and cast-iron, stone and wood, that the "sets" produced in bodies are proportional to the squares of the weights applied; and, therefore, that small weights produce a permanent set in bodies.*

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* This article will be given in full.

*Temperature of the Air at different heights.*—The following is a description of the telegraph thermometer devised by Professor Wheatstone, of London, and to be applied in their experiments with "captive balloons," by the committee of the Association:

"The telegraph thermometer which is intended to be carried up by the balloon, weighs, with its case, about four pounds. It is thus constructed: the movement of a small clock causes a vertical rack to ascend and descend regularly in six minutes, three minutes being occupied in the ascent, and three in the descent. The rack carries a fine platina wire, which moves within the tube of a thermometer; the extent of motion of this wire corresponds with 28° of the thermometric scale, but it is capable of adjustment, so that it may pass over any 28° of the range. Two very fine copper wires, covered with silk, and of sufficient length to reach from the ground to the balloon, when at its greatest elevation, are connected with the instrument in the following manner: the extremity of one wire is connected with the mercury in the bulb of the thermometer, and that of the other wire with the frame of the clock, which is in metallic continuity with the platina wire. On the ground, the lower extremities are joined together; in the wire whose opposite end is connected with the mercury in the thermometer, a sensible galvanometer is interposed, and in the course of the other wire a single, very small, voltaic element is introduced. The galvanometer having been properly adjusted to its zero point, it will remain so during the time that the platina wire is not in contact with the mercury in the tube, but the needle will deviate so soon as the contact takes place, and will remain deflected until contact is again broken during the ascent of the rack. During each half second of time, corresponding with the beats of the clock, the wire moves through the 360th part of its range, and a different point of the range consequently corresponds with a different beat, or half second of each alternate three minutes. If, therefore, an observer below be furnished with a chronometer, timed to coincide with the clock in the balloon above, and note at what instant the needle of the galvanometer is deflected, he may infer from that observation the temperature indicated by the thermometer in the balloon; for, according to the different expansion of the mercury in the thermometer, the contact is broken at a different half second. Should the rates of the two time pieces not exactly correspond at the conclusion of a series of observations, the results will not be vitiated, as a correction may be easily made. It is intended to add to this apparatus a wet bulb thermometer; this will involve only the addition of another platina wire to the rack, and of another insulated wire, reaching from the balloon to the earth, with its interposed galvanometer.

"For other meteorological instruments, the indications of which are to be transmitted to a distance, I occasionally employ the agency of electro-magnetism to ring a bell, to mark with a type, or pencil, &c.; but for the purpose in question, such methods cannot be so conveniently employed as the deflexion of the needle of a galvanometer on account of the necessity of having the long conducting wire extremely fine, in order to avoid adding too much to the weight of the balloon. If the electro-motive force of the rheomotor were increased, which it would be necessary to do were stronger currents required, sparks would occur at the surface of contact of the mercury, which would produce injurious effects."

*Two new metals.*—Professor Mosander in examining the mineral yttria has found two new metallic oxides, the bases of which he calls erbium and terbium.

*Geological survey of Great Britain.*—Attached to the corps which is carrying on the trigonometrical survey of Great Britain, are geologists who carry on simultaneously with the trigonometrical operations a geological survey. Characteristic specimens of the different strata, and of the fossils contained in them, are deposited in the "Ordnance Museum," which it is intended, eventually, to throw open to the public.

*Motion of glaciers.*—Mr. Hopkins, with a view to elucidate the theory of the motion of the glaciers, made the following experiments: "A slab of sandstone, prepared to be laid down as a part of a common flagstone pavement, was so arranged as to be easily placed at any proposed inclination to the horizon. The surface of the slab, so far from being polished, retained the grooved marks of the instrument with which the quarry-man had shaped it. A quantity of ice was placed on the slab, within a frame nearly a foot square, intended merely to keep the ice together, and not touching the slab, with which the ice alone was in contact. The following were results obtained in one set of experiments, the ice being loaded with a weight of about 150 lbs.:

| Inclination of the planes, | 3° | 6° | 9° | 12° | 15° |
|---|---|---|---|---|---|
| | Inches. | | | | |
| Mean space for one hour, | 0.31 | .62 | .96 | 2. | 2.5 |

When the weight was increased, the rate of motion was also increased. The least inclination at which sensible motion would take place, was not determined; but it was ascertained that it could not exceed *half a degree* in the case of a smooth but unpolished surface. With a *polished* surface of a marble slab, the motion of the ice indicated a deviation from horizontality with as much sensibility as water itself. It will be observed, in the results above given, that (1) the motion was unaccellerated; and (2) it increased with the inclination, and (when the inclination was not greater than nine or ten degrees,) in nearly the same ratio; and (3) the rate of movement was of the same order of magnitude as in actual glacial motion, which may be stated generally, in cases yet observed, never to exceed two feet a day. The extremely small friction between the plane and the ice, indicated by the small inclination necessary to produce motion, was manifestly due to the circumstance of the lower surface of the ice being in a state of gradual disintegration, which, however, was extremely slow, as proved by the small quantity of water proceeding from it. In the application, therefore, of these results to the case of actual glaciers, it was necessary to show that the temperature of their lower surfaces could not generally be less than 32° Fahr. Such, the author stated, must necessarily be the case, unless the conductive power of ice was greater than it was deemed possible that it could be."

The temperature at which the experiments were made is not stated.

*Earthquakes in Scotland.*—In the course of the year from July 1842 to July 1843, no less than thirty slight shocks of earthquakes have occurred at Comrie, in Perthshire.

*Permanent expansion of solids by heat.*—Mr. Scott Russell states that cast and malleable iron and brass undergo a permanent expansion when heated, not returning, on cooling, to their former dimensions. This is contrary to the results hitherto obtained in regard to these bodies.

*Meteorological report.*—The abstract, by Col. Sabine, of the report by Sir J. F. W. Herschel, from the committee on the reduction of meteorological observations, embracing the series of equinoctial and solsticial observations for 1835 to 1838 both inclusive, cannot be abridged, and will be given in full in a future number.

*Diurnal changes of the magnetic elements.*—The reductions of the magnetic observations at Dublin, made under the direction of Professor Lloyd, exhibit the following facts in regard to diurnal changes at that place. The horizontal intensity has two maxima and two minima during the twenty-four hours, the former at 5 A. M. and 6 P. M., and the latter between 1 and 3 A. M. and 10 A. M. The first named are small compared with the second, and disappear in the summer months; in the winter the evening maximum appears to divide into two. The time of occurrence of the morning maximum depends upon the hour of sun-rise. The daily range of force in July is .0045 of the whole intensity, and in January but .0008: the total intensity varies but little through the day. It is least about 9 A. M., and then increases, having a double maximum in the afternoon. The chief apparent changes in the two components of the intensity, the horizontal and vertical, are due to changes of dip (inclination.) The dip is greatest between 10 and 10½ A. M., and least about 6 P. M. The daily range in the early part of the year is about two minutes, and increases to more than double that amount in summer. The diurnal variation (change of declination) follows a different course at different periods of the year. The mean change for the whole year shows a small easterly motion of the north end of the needle in the morning, attaining a maximum about 7 A. M. The north end of the magnet then moves rapidly westward, attaining its extreme position at 1h. 10m. P. M.: the easterly deviation again becomes a maximum about 10 P. M. The mean daily range is about 9.3 minutes. During the summer months the morning maximum at 7 A. M. is more marked, and the evening maximum disappears, while in winter the reverse is the case. The greatest daily range is in summer, and about 13.7 minutes; the least, in winter, and about 7.2 minutes. The diurnal changes in the direction of the magnetic force appear to connect it with the diurnal movement of the sun.

*Artificial magnets.*—Dr. Scoresby finds that for large magnets consisting of many bars, or of heavy masses, the best cast-steel made as hard as possible, is the most effective material; while, for small magnets, or thin compass needles, other steel, or cast-steel tempered, is better. The dimensions of a magnetic bar being doubled, and the bar saturated, the effective force is increased only five or six times. The rule in regard to the use of hard cast-steel for bar magnets does not hold with compound horse-shoe magnets, a softer material being required to produce the most powerful combination with this form of magnet.

*Report of the committee on the form of Ships.**—This report, by Mr. Scott Russell, includes 20,000 observations, on more than one hundred vessels of different forms. It is understood to be now ready for publication. One of the general laws announced by Mr. Russell, is that each velocity of motion has a corresponding form and dimension producing with it the least resistance. In a comparison of four different vessels of the same length, breadth, depth, area, and form of midship section, and loaded to the same weight, displacement, and draught of water, the form of the water-lines being the only difference in the models, the following results were obtained. No. 1, was of the wave form of water-line; No. 3, the "old form," nearly the reverse of the former; No. 2, intermediate between No. 1 and 3, and No. 4, intermediate between No. 1 and 2.

| Miles per hour. | Resistance in pounds. | | | |
|---|---|---|---|---|
| | No. 1. | No. 4. | No. 2. | No. 3. |
| 3 | 10 | 11.3 | 12 | 12 |
| 4 | 18 | 21 | 22 | 23 |
| 5 | 28 | 35 | 38 | 42 |
| 6 | 39 | 56 | 61 | 72 |
| 7 | 52 | 84 | 96 | 129 |

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* These experiments have occupied more than five or six years, and have cost more than four thousand dollars.

# INDEX.

Acid of Commerce, purification of hydrochloric 143
Acid, decomposition of carbonic, under the heat of the sun, 419
Aerial Navigation, principles of 132, 202
Air, temperature of the, at different heights, 421
Alloy, Mallet on metallic 325
Alloys, elasticity, &c. of 345
Amalgum of sodium, a galvanic pair, 346
Analysis, application of the electrotype process in conducting organic 339
Aqueducts and Viaducts, Vignoles' lecture on 23
Architecture and Gardening, Loudon on landscape 47, 89, 182, 265
Artificial magnet, 424
Asphaltic pavements, report on 147
Axles, causes of the breakage of the journals of railway 178
———, description of Hancock's railway 181
———, experiments on the strength of solid and hollow 332

Bakewell, T. W. on strength of cylindrical boilers, 100, 206
Beacon erected at the harbor of Black Rock, description of a wrought-iron, by Capt.
W. H. Swift, 385
Bicarbonate of soda, preparation of 72
Bissell's pneumatic car, or carriage, springs, report on 168
Blow-pipe, Moss on the 104
Boiling point of liquids, 358
Brass and copper, covering with platina 357
—————————, tinning and zincing, by the moist way, 358
Breakwater, Norton's lotus floating 181
Bricks, unburnt, from the Pyramids of Daskmoor, 181
Bridges, proposal to improve the design of arched 80
Bronzing, galvanic 356
Buckingham palace, description of roofs over 98

Carbonic acid, decomposition of, under the light of the sun, 419
Carriage springs, report on Bissell's pneumatic car, or 168
Carriages, injuries done to roads by the passage of 251
Caspian Sea, level of the 346
Cemeteries, public, Trautwine on 46
—————————, Loudon on 47, 88, 182, 265
Chemical rays in light upon chlorine, action of the 419
Chlorine, action of the chemical rays in light upon ib
Civil engineering, Vignoles' lecture on 20, 73, 170, 246, 302, 390
Combination, on the heat of 419
Comets, heat from 345
Copper and brass, covering with platina 357
—————————, tinning and zincing in the moist way, 358
Copper, test for 359
Corona and beads during a solar eclipse, 347
Curves, Vignoles' lecture on railway 20

Daskmoor, unburnt bricks from the pyramids of 181
Decomposition of carbonic acid under the light of the sun, 419
Dover, Gen. Pasley on the mining operations near 28
Dynamometer for measuring steam, or water, power, 275

Earthquakes in Scotland, 423
Eclipse, corona and beads during a solar 347
Elasticity, &c. of alloys, 345
————— destruction of by small strains, 420

Electricity evolved by the friction of water and steam on other bodies, 141
———, from steam, 347
———, resistance of earth to the motion of 345
Electro-chemical silvering, 356
Electrotype process in conducting organic analysis, application of the 339
Eliet, jr., C. on cost of transportation on railroads, 316, 361
Etching on hardened steel, &c. by electricity, 340
Excavator, Otis' steam 175, 309
Expansion of solids by heat, permanent 423
Explosion of the Dover cliff, account of 28
Explosions of steam boilers, 139
Explosive force of oxygen and hydrogen gases, experiments on the 210

Founding, on the processes of iron 56, 116, 191, 269
Fires, on colored 358
Flying machine, steam power of Henson's 281
——— machines 336
Friction of water and steam against other bodies, on the electricity evolved by 141

FRANKLIN INSTITUTE.

Committee on Science and the Arts.
Report on the best modes of paving highways, 145, 217
——— Bissell's pneumatic car, or carriage spring, 168
Committee on Exhibitions.
Address delivered at the close of the thirteenth exhibition, by John Wiegand, Esq., Chairman, 394
Report on the thirteenth exhibition of American Manufactures, 397

Galvanic Bronzing, 356
——— induction, 344
——— pair, amalgam of sodium, a 346
Galvanized iron, 144
Gardening and architecture, Loudon on landscape 47, 89, 182, 265
Gases, experiments on the explosive force of oxygen and hydrogen 210
Geological survey of Great Britain, 422
Gilding and silvering by immersion, methods of 142
——— gilding by precipitation—*patent*, 287
Glaciers, motion of 422
Glass, images on 347
Glue, Jefferies' marine 197
Greenwich pier, account of the failure of the 180
Great Britain steamer, description of the 306
———, geological survey of 422

Heat from comets, 345
—— of combination, on the 419
——, permanent expansion of solids by 423
Henson's flying machine, steam power of 281
Highways, report on the best modes of paving 145, 217
Hot-blast, legal decision on Neilson's patent, 135
Hydrochloric acid of commerce, purification of 143
Hydro-electric currents from thermo-electric, 345
Hydrogen gases, experiments on the explosive force of oxygen and 210

Images on Glass 347
——— Resin, 346
Iron beacon erected at the harbor of Black Rock, description of a wrought, by Capt. W. H. Swift, 385
Iron by the hot-blast, legal decision on Neilson's patent for making 135
—— founding, on the processes of 56, 116, 191, 269
—— galvanized, 144
—— rails, making direct from the ore, 125
—— rails for railways, Trautwine on 1

Jefferies' marine glue, 197
Jupiter's moons, 346

Lamp burners, on the perfect ventilation of 128
Lead, on the action of water on 284
Liquids, boiling point of 358
Lecture rooms, form of 419
Light, action of the chemical rays in, upon chlorine, ib.
—— of the sun, decomposition of carbonic acid under the ib.
Long Island Sound, description of a wrought-iron Beacon erected at the harbor of Black Rock, by Capt. W. H. Swift, 385
Lotus floating breakwater, Norton's 181
Loudon's principles of landscape gardening and architecture, applied to public cemeteries, 47, 88, 182, 265

Magnetic elements, diurnal changes of the 423
Magnets, artificial 424
Marine Glue, Jefferies' 187
Metal, another new 345
Metals, two new 422
Metallic alloy, 325
Meteorological observations, 216, 288, 360
———— report 423
Mining operations near Dover, Gen. Pasley on the 28
Morin's experiments on turbines, 234, 279, 370
Morris, E. on a new application of railways, 313
———— experiments on the useful effects of turbines in the United States, 377
Möser's discovery, effect neither due to light nor heat, 68, 110
Moss, T. F. remarks on the blow-pipe, 104

Nautical inventions, Clement's 348
Navigation, principles of ærial 132, 202
Neilson's patent hot-blast, legal decision on 135
Norton's lotus floating breakwater, 181

Oil, of calming the waves of the sea, experiments to verify the property ascribed to 341
Ores used at Freiburg, 109
Organic analysis, application of the electrotype process in conducting 339
Otaheite, tides at 343
Otis' steam excavator, 175, 309
Oxygen and hydrogen gases, experiments on the explosive force of 210

Palladium, its extraction, alloys, &c., 329
Pasley, Gen. on the mining operations near Dover, 28
Paving highways, report on the best modes of 145, 217
——— roads, &c. with wood—*patent*, 286
Pavements, asphaltic, report on 147
————, stone, report on 160
————, tesselated, ancient and modern, 40
————, wooden, report on 149
Photographic processes, improvements on 187
Pier, account of the failure of the Greenwich 180
Platina, covering copper and brass with 357
Poncelet M. on stability of revetments, and of their foundations, 10
Public cemeteries, Trautwine on 46
——————, Loudon on 47, 88, 182, 265
Pyramids of Daskmoor, unburnt bricks from the 181

Railroads, Ellet on cost of transportation on 316, 361
Railway axles, causes of the breakage of the journals of 178
——— axle, description of Hancock's 181
——— curves, Vignoles' lectures on 20
——— estimates, Vignoles' lectures on 76, 170
——— crossing by common roads at same level 85

Railways, Morris on a new application of . . . 313
———, Trautwine on rails for . . . 1
———, Vignoles' lectures on the upper works of . . 24, 73
———, wheels and tires of wheels for—*patent*, . . 212
———, working expenses of, Vignoles' lectures on . . 246, 302, 390
Resin, images on . . . 346
Revetments, and of their foundations, Poncelet on the stability of . 10
Roads by the passage of carriages, injury done to . . 251
Roofs over Buckingham palace, description of . . 98

Science, hasty generalizations in . . . 347
———, expenditure for the promotion of . . 420
Scotland, tides on the eastern coast of . . 420
————, earthquakes in . . . 423
Sea, new mode of measuring the . . . 344
Ships, report of committee on the form of . . 424
Sillomêtre, on the . . . . 348
Silver and other metals from their compounds, separating—*patent*, . 214
Silvering and gilding by immersion, methods of . . 142
————, electro-chemical . . . 356
Soda, preparation of bicarbonate of . . . 72
Sodium amalgum of, a galvanic pair, . . . 346
Solar eclipse, corona and beads during a . . 347
—— spectrum, on the parathermic rays of the . . 187
Solids, permanent expansion of, by heat, . . 423
Speaking machine, . . . . 345
Spring contractor, Lieut. Rankine's . . . 338
———, report on Bissell's pneumatic car, or carriage, . . 168
Stanhope's composition for covering roofs, . . 98
Stars, catalogue of the . . . . 418
Steam boilers, on the strength of cylindrical . . 54, 100, 209, 279
—————, explosions of . . . 139
Steam and water against other bodies, on the electricity evolved by the friction of 141
——— excavator, Otis' . . . . 175, 309
———, electricity from . . . 347
———, or water, power, dynamometer for measuring . . 275
——— power for Henson's flying machine, . . 281
Steamer, description of the Great Britain . . . 306
Stockings, drawers, &c., manufacturing—*patent*, . . 286
Steel plates, &c., etching by electricity on hardened . . 340
Stone pavements, report on . . . 161
Sun, decomposition of carbonic acid under the light of the . 419
Survey of Great Britain, geological . . 422
Swift, Capt. W. H., description of a wrought-iron beacon erected at the harbor of Black Rock, by . . . . 385

SPECIFICATIONS OF PATENTS.
  Drawers, hose, &c., manufacturing—*Keene's*, . . 286
  Oxides of metals, separating silver, &c.—*Mullin's*, . 214
  Paving roads, ways, and other surfaces—*Dotchin's*, . . 286
  Plating by precipitation—*Talbot's*, . . 287
  Weighing machine—*Cotton's*. . . . 285
  Wheels and tires of wheels for railways—*Banks'*, . 212

Temperature of the air at different heights, . . 421
Tesselated pavements, ancient and modern, . . 40
Test for copper, . . . . 359
Thermo-electric from hydro electric currents, . . 345
Tides at Otaheite, . . . . 343
—— of the eastern coast of Scotland, . . . 420
Timber, preserving by Payne's patent, . . . 88
Tinning and zincing copper and brass in the moist way, . 358
Trautwine J. C. on public cemeteries, . . 46
——— ———— rails for railways, , . . 1

Transportation on railroads, Ellet on cost of . . 316, 361
Turbines, Morin's experiments on water-wheels called . . 234, 289, 370
———, in the United States, experiments on the useful effect of by E. Morris, C. E., 377

Viaducts and Aqueducts, Vignoles' lectures on . . 23
Ventilation of lamp-burners, on the perfect . . 128
Vignoles' lectures on civil engineering, . . 20, 73, 170, 246, 302, 390

Water, action of, on bodies, . . . 345
—— and steam against other bodies, on the electricity evolved by the friction of 141
—— on lead, on the action of . . . 284
—— power, dynamometer for measuring steam, or . 275
Water-wheels, coefficient of laboring force in . . 62
———wheel, Mallet's close-breast for an overshot . 177
———wheels, Morin's experiments on . . . 234, 289, 370
————, Morris' experiments on, in the United States, . 377
Waves of the sea, experiments to verify the property ascribed to oil of calming the 341
Weighing machine—*patent*, . . . 285
Well sinking, legal decision regarding . . 312
Wheels and tires of wheels for railways—*patent*, . . 212
White lead, making—*patent*, . . . 214
Winds, observations on the direction and force of . . 420
Wood, paving roads, &c., with—*patent*, . . . 214
Woolen factory for Turkey, . . . 311
Wooden pavements, report on . . . 149

Zincing and tinning copper and brass in the moist way. . . 358

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